



Department of Energy
Office of Civilian Radioactive Waste Management
Yucca Mountain Site Characterization Office
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JUL 03 1997


OVERNIGHT MAIL

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SUBMITTAL OF PARTICIPANTS' MONTHLY PROGRESS REPORT

As you have requested, the U.S. Nuclear Regulatory Commission is on distribution to receive a copy of the Yucca Mountain Site Characterization Project participants' monthly status reports on a regular basis. Enclosed is the U.S. Geological Survey Progress Report for May 1997.

If you have any questions, please contact April V. Gil at (702) 794-5578.


Stephan J. Brocoum
Assistant Manager for Licensing

AML:AVG-1821

Enclosure:
Ltr, 06/11/97, Craig to Kozai, w/encl

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INFORMATION ONLY

June 11, 1997

Wayne Kozai
Yucca Mountain Site Characterization
Project Office
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P.O. Box 30307
Las Vegas, Nevada 89036-0307

SUBJECT: Yucca Mountain Project Branch - U.S. Geological Survey (YMPB-USGS)
Progress Report, May, 1997

Attached is the USGS progress report in the required format for the month of May, 1997.

If you have any questions or need further information, please call Raye Ritchey Arnold at (303)236-0516, ext. 282.

Sincerely,

Raye R. Arnold

for Robert W. Craig
Technical Project Officer
Yucca Mountain Project Branch
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U. S. GEOLOGICAL SURVEY EXECUTIVE SUMMARY

May, 1997

WBS 1.2.3.1 Coordination and Planning

U. S. Geological Survey - Yucca Mountain Project Branch is currently processing 190 scientific papers prepared by USGS authors. Of these, 101 are related to geologic studies and 89 to hydrogeologic studies. In addition, 50 abstracts are being processed, as well as 17 reports by LBL personnel.

WBS 1.2.3.2 Geology

Geologic Framework

The site area geologic map (scale 1:24,000) has been completed and submitted for field review. Preparation of cross sections and an accompanying text that describes structural features and relationships is in progress. Evaluation of structural controls on the distribution of chlorine-36 in the ESF continued, with comparisons being made between surface geologic mapping and full-periphery geologic mapping in the ESF. Discussions were held with LANL scientists to coordinate the preparation of scheduled milestone reports on chlorine-36 distribution.

The correlation of borehole geophysics with lithostratigraphy continued as part of the site stratigraphic studies and the 3-D modeling effort by M&O personnel. A workshop was held May 6-7 at the Sample Management Facility to discuss QA procedures and the selection of the stratigraphic contacts to be used in modeling. As a result of the workshop, the number of contacts were tentatively increased to 47 from the original 30 together with significant increases in both QA documentation and technical review of the interpretations. Additional discussions are being held among all the participants, however, to attempt to decrease this large number of lithostratigraphic contacts that are currently being considered for 3-D modeling in order to meet completion schedules.

Texts, figures, and tables for the sections on Site Stratigraphy and Site Structure for the PISA report were completed and submitted on May 29.

Geologic mapping in the ESF was accomplished as follows: (1) full-periphery geologic mapping was completed to station 78+00; (2) detailed line survey at the heading was completed to station 78+00; (3) stereophotography was completed to station 78+07.60; (4) full-periphery geologic mapping in Alcove #6 was completed to station 1+51; (5) detailed line survey in Alcove #6 was completed to station 1+55; (6) full-periphery geologic mapping in Alcove #7 was completed between stations 0+36 and 0+93; and (7) detailed line survey in Alcove #7 was completed to

station 0+44.

Seismotectonic Studies

A report on the results of the feedback workshop on ground motion (April 16-18) was completed and submitted to DOE on May 13. The report summarizes the discussions held among the ground motion experts on the different ground-motion attenuation models being evaluated, as well as on the preliminary modeling of scenario earthquakes that were selected by the seismic source characterization panel. Appropriate values for kappa (spectral decay parameter for near-surface ground-motion attenuation) were subjects of further discussion through the month of May as the experts continued to prepare their final assessments.

A summary of the issues, interpretations, and models presented at the April 14-16 seismic source feedback workshop was completed and submitted to DOE on May 19. Because all six of the fault displacement models that were presented at the April workshop were found not to be at the same level of maturity, a final fault displacement workshop is scheduled for June 2 so that all of the seismic source characterization expert teams will have a clear understanding of each of the models and assessments that are being considered. The expert teams also continued preparation of final reports that present justifications of the logic trees that were developed for their characterization of seismic sources.

Sections on regional geologic setting, seismicity and seismic hazards, surficial processes, and tectonic models for the PISA report were completed and submitted on May 29.

WBS 1.2.3.3 HYDROLOGY

Regional Hydrology

Efforts continued on preparation of the regional saturated-zone synthesis report. A draft of the report was completed and submitted for technical review on May 1, completing level 4 milestone SPH23BM4 [Memo to TPO: Review draft Regional SZ synthesis report/Climate change]. Comments were received from both technical reviewers, and work immediately began on responses to review comments and on revision of the report.

Collection of site stream-flow data continued during May. Streamflow and precipitation data collected through April have been compiled and stored in project files. During the month, routine maintenance was made on the three recording streamflow gages along Fortymile Wash. Runoff was neither observed nor reported during May for the three gages.

In unscheduled work, staff reviewed a report that documents pneumatic testing in ESF alcoves; additional staff worked on software QA for "Zonebudget," a post-processor module for MODFLOW and MODFLOWP. Staff presented an update on regional modeling activities to NWTRB members in Las Vegas on May 14 and 15.

Unsaturated-Zone Hydrology

Monitoring of the unsaturated-zone (UZ) borehole instrumentation continued during May. Borehole data from NRG-7a, UZ#4, UZ#5, UZ-7a, and SD-12 were transferred to Denver, converted to engineering units, and archived to optical disk on a routine basis throughout the month. Daily EKES files were checked for shelter activity. Sensor readings were checked daily as well for unusual occurrences, and statistical outliers were flagged.

Several trips were made to field sites for correction of generator, UPS, and chiller problems. One thermistor was calibrated. Eight site visits were made for routine generator maintenance, and four site visits were made to correct UPS and generator problems. The generator at UZ-7a was swapped for another on May 22. One trip was made to correct unexplained faults with the data-collection system at UZ#4 and #5, and another was made to correct communication hang-ups at SD-12. Two trips were made to SD-12 to correct clock problems.

Investigations of matrix properties of hydrologic units continued during May. Samples from the main drift of the ESF have been run on the high-pressure permeameter, although such analyses are not yet being done routinely. Problems were found with the flow cells for automated data collection, and a pipette system is currently being used with a calibrated transducer to measure the height of the water column which is then related to outflow. Samples are being run in the centrifuge to collect moisture-retention curves which will be correlated to unsaturated conductivity measurements. The original centrifuge has had the rotating seal reinvented to accommodate both low and high flow rates. It is currently being tested. The filter-paper water-potential measurement technique is still being evaluated as problems were found with the technique. Samples from the two main drift niches have been requested but not yet received.

In support of E&I Design Basis modeling, USGS staff responded to a request for a second presentation on the spatial distribution of infiltration. In addition, a discussion on the potential for climatic change will be added to the response.

Preparation of plans for *in situ* field estimation of percolation flux rate continued during the period. Data collection and analysis continued on the time-domain reflectometry (TDR) systems and heat-dissipation probes (HDP) installed in the ESF. The TDR and HDP instruments in the south ramp were covered with plastic in an attempt to rewet the rock and calculate a sorption water-retention curve and to determine current field water potential and water content. Plans were further developed for implementing an instrumentation scheme for the East-West drift to estimate the spatial variability of percolation flux. Rock samples, collected from the main drift at 20-m spacings, are still being analyzed in the laboratory to determine bulk properties and hydraulic conductivity. These properties will help in the analysis of data from the main drift and the East-West drift.

Air-permeability and hydrochemical testing in the ESF continued during May with initiation of thermal and pneumatic testing in the northern Ghost Dance fault (NGDF) alcove on May 15. The pneumatic monitoring in borehole #1 showed pressure spikes from the injection of drilling air in borehole #2. The pressure spikes will aid in identifying fracture connections between the

two boreholes. Excavation of the southern Ghost Dance access drift (SAD) an additional 15 m was completed. Following construction, the borehole required additional drilling and cleaning and is expected to be ready for testing on June 2. Equipment for gas sampling and pneumatic monitoring was moved underground in anticipation of beginning testing of the western GDF trace the first week of June.

Collection of temperature and relative humidity data continued at eight sites in the ESF. Wind-speed data are currently being collected at five sites. Installation of four additional wind-speed monitors (plus relative humidity and temperature) is completed. Barometric pressure, temperature, and relative humidity data are being collected at two locations. Data collection from heat-dissipation probes and TDR probes in Alcove 3 continued. Data collected between February 1, 1997, and July 1997 are being assembled for a data package.

Sets of tensiometers and heat-dissipation probes continued to monitor the dry-out of the tunnel wall. A 5- x 5-ft sheet of plastic was installed over each of the monitoring sites to see if that section of the tunnel wall would "wet up." The plastic will restrict water evaporation to the tunnel and should cause the instruments to show an increase in the rock water potential. This work is being done to support future ESF monitoring activities.

Investigation of south ramp ESF hydrology continued with collection and processing of data from sets of tensiometers and heat-dissipation probes installed at ESF Stations 66+99 and 67+33. TDR instrumentation was installed at Station 66+99 to monitor water content from the ESF wall to depths of 15 cm and 30 cm. The areas around these instruments are still covered with plastic to monitor the recovery of the rocks from the drying effects of tunnel ventilation and to interpret anomalies in the collected data. Problems with the instrumentation and the techniques used to collect data have resulted in some data loss, but these problems are being resolved through training and careful monitoring of the collected data. Evaluation of the filter-paper technique to determine the *in situ* water potential of cores continued, but problems with this technique have been identified. Water-retention curves for the filter paper are being measured in the laboratory, and practical techniques for using the filter paper method are being investigated. The practicality of using heat-dissipation probes and/or tensiometers to measure the *in situ* water potential of core samples is being investigated. The prototype packer installed in ESF-SR-MOISTSTD#1 continued to collect data. Differences between the water potential measured with the tensiometer and the water potential measured with the heat-dissipation probe continue to be evaluated. A packer with a heat-dissipation probe, a tensiometer, and a psychrometer was built but has not yet been installed in the ESF.

Studies to evaluate lateral diversion in the PTn continued with laboratory experiments to evaluate methodology to measure water potential of core samples that will be collected from the north-ramp boreholes. High-resolution water-potential measurements are crucial, especially in the relatively high-potential rocks, as relative differences need to be discerned in order to calculate flux estimates through the various rock layers. A filter-paper method currently is being evaluated along with rock-touch tensiometers and heat-dissipation probes used in the lab to measure the water potential of preserved rock samples. These measurements will be compared with data collected from *in situ* measurements using heat-dissipation probes and tensiometers

with packer strings. No data have yet been collected.

In the drift-scale flux and niche study, drilling has been initiated at Niche #2, located at ESF Station 36+50. Exterior borehole drilling and pneumatic testing continued at Niche #1. Neutron logs were run before pneumatic testing was initiated. Analysis of the neutron logs has been initiated and will be compared to the core analysis to develop a neutron-probe calibration equation.

Unsaturated-zone hydrochemical studies continued during the period with multiple active efforts. Repair of the liquid scintillation counter appears to have solved the problem of failed calibration runs and the disconnection of the communication line between the instrument and the recording PC. The cause of the slightly higher background count rate still needs investigation. Seven core segments (from four samples) drilled in ESF Alcove #5 were received. Extractions for tritium and stable-isotope (D and ^{18}O) analyses were made. Results of analyses are expected by the first week of June. Data packages for the related level 4 milestone are being prepared. Water collection by compression and distillation methods during May was recorded in the water-collection database, and the tritium data base was updated. Pore water from four SD-7 core samples (Calico Hills, Topopah Spring, and two from the Prow Pass) was collected using one-dimensional compression methods. Seven molecular-sieve collection cylinders were degassed, and eight storage cylinders were heat-evacuated (to remove residual CO_2 gas and H_2O vapor) and leak-tested. Staff prepared seven CO_2 gas samples from borehole UZ-14 for ^{14}C analysis. Seven whole-gas samples for were prepared $^{13}\text{C}/^{12}\text{C}$ analysis.

In unscheduled work, staff prepared and shipped core samples to G. Davidson at the University of Arizona for extraction of dissolved CO_2 and acidification of subsequently precipitated calcite from densely welded tuff for carbon-isotope analyses. Staff attended the PISA meeting in Denver on May 20. The purpose of the meeting was to receive guidelines on the regulatory framework within which the PISA will be prepared. USGS staff also provided a report on the status of the geochemistry and isotope section to foster integration among the support authors.

Saturated-Zone Hydrology

Processing of saturated-zone (SZ) hydraulic and tracer-test data obtained from the C-hole complex continued during May. Preparation continued of data packages (for tracer concentrations of Pyridone and 2,6 difluorobenzoic acid, and for pressure and water-level data from C-hole wells and nearby wells UE-25 ONC-1, USW H-4, UE-25 WT#14, UE-25 WT#3, and UE-25 p#1, respectively). Work also continued on a report describing all results of hydraulic and tracer testing in the Bullfrog and Tram intervals in C-hole wells obtained since May 1995. Continuation during May of the multiple-well convergent tracer test with UE-25 c#3 as the pumping well resulted in Pyridone breakthrough-curve data showing a steady rise in concentration to a broad peak of approximately 150 parts per trillion, slightly higher than previously reported values.

Monitoring of potentiometric levels during the period provided further information. For the

month of May, four zones in four wells were monitored hourly with transducer measurements. Monitored wells included UE-25 WT#3, UE-25 WT#14, UE-25 p#1 and USW H-4 (upper interval). Data were retrieved from recorders at those wells. The data package for the 1996 hourly water-level data was completed for submittal to the Records Center.

Acquisition of water-table Eh and pH data continued with a current focus on existing ground-water chemistry. Staff completed uranium chemistry and isotope analysis of SZ water from the C-hole complex obtained after extensive pumping earlier in the year. Two replicate analyses of water collected in February 1997 are very similar to compositions of water collected in May 1995 with uranium concentrations of about 1.1 ppb and measured $^{234}\text{U}/^{238}\text{U}$ activity ratios of 8.00 to 8.08. Therefore, $^{234}\text{U}/^{238}\text{U}$ data support tapping of a single, well-mixed reservoir both before and after extensive pumping. Staff constructed a database of SZ hydrochemical analyses and began entering major-ion and stable and radiogenic isotope data from published and non-published sources. The initial efforts concentrate on data from the immediate Yucca Mountain vicinity and incorporate an evaluation of the data quality prior to entering it into the database.

Calibration of the SZ site flow model continued, using different combinations of specified pressure and flux boundary conditions and different combinations of adjustable parameters. This work has continued beyond the original cutoff date of April 30 in order to obtain a more acceptable calibration. The calibration of the model as of May 23 was improved over the April 30 version and is essentially "frozen" on that date for submission to DOE and documentation. Work on obtaining an improved calibration will continue, however, under a different summary account.

Verification of interpolated specified pressures developed for the model was done by allowing the model to estimate hydrostatic boundary conditions for nodes located beneath the upper side edges of the model grid, at which pressures associated with hydraulic head were specified. The pressures estimated by the model were within 0.1 percent of the original specified pressures.

Results from forward runs of the FEHMN model of the site were represented as contours of hydraulic head along each vertical side of the model. Preliminary analysis shows downward flow in the north and upward flow in the south by simple specification of hydraulic head along the top edges of the model based on observed head values. Representation of results in terms of hydraulic head allows greatly enhanced interpretation of the results.

Enhancements to the modeling effort continued. Testing of an impedance parameter (AIPED) to flow within FEHMN was performed to see what effect, if any, this parameter has on flow within the model domain and at the boundaries. Vector plots for several values of AIPED were developed which show that impedance can greatly affect the resulting flow. After substantial testing of the AIPED impedance parameter, a comparison of the governing equations with FEHMN to those used in MODFE (the USGS modular finite element model) was done for comparison purposes. A new finite-element mesh was developed which pertains to a conceptual model treating the apparent large hydraulic gradient as associated with a perched water body. This mesh will be used to examine alternate models of the flow system. A formal request for the latest LANL QA-approved version of the FEHMN executable code was submitted and processed

by LANL personnel. Work began on calculation on particle flow paths and fluxes for present, past, and future climatic conditions, based on regional flow model output. Work also began on incorporation into the regional flow model of data recently obtained by USGS Nevada District concerning evapotranspiration from Ash Meadows. This information will be used as part of the sensitivity analyses for total-system performance analysis and viability assessment (TSPA-VA). A preliminary version of the site SZ flow model was delivered to PA on May 12. Staff submitted a revised plan for performing sensitivity analyses related to present, past, and future fluxes to PA and provided feedback on the workshop summary being prepared by PA.

Work on the site SZ synthesis report continued, with ongoing effort on writing various parts of the report, in particular the sections on Hydrogeologic Framework and Hydrogeologic Units. Revisions were made to a table of hydraulic characteristics. The table was completed and submitted to a contractor for a data-transcription review.

Planning continued for the SZ flow model expert elicitation. USGS staff met with other members of the Methodology Development Team on May 5 in Las Vegas to go over selection of Panel members and to outline the agenda for the first workshop; efforts continued through teleconferences. Hydrologic modeling team members began preparations for the first workshop, scheduled for June 4 to 6 in Denver.

Progress occurred toward publication of hydrologic results. The report *Water levels in the Yucca Mountain area, Nevada, 1995*, by R.P. Graves and R. Goemaat (approval as USGS Open-File Report 97-101 in February 1997), was edited, and electronic copy was transferred to the Colorado District Reports Unit on May 28. Staff reviewed a report *Analysis of aquifer tests conducted in borehole USW G-2, 1996, Yucca Mountain* by G.M. O'Brien.

In unscheduled work, staff supported the PISA report with contributions to chapter 3.5 (Hydrogeologic Systems) and participated in the SZ expert elicitation workshop. Staff continued work on analysis of frequency response of water levels at Yucca Mountain in order to estimate hydraulic characteristics of the aquifer. Staff also prepared a presentation to be made at the Biosphere PA Abstraction/Testing Workshop that will be held on June 2 and 3.

WBS 1.2.3.6 CLIMATOLOGY and PALEOHYDROLOGY

Investigations of lakes, playas and marshes for details of climatic history continued during May. Staff spent part of the month analyzing diatom data from the Owens Lake core. Examination of those data from several interglacial to glacial sequences suggests that the transitions from interglacial to glacial intervals may be more rapid than suspected. The transition from a fully alkaline-saline lake (interglacial interval) to a through-flowing fresh-water lake receiving significant flow from the Sierra Nevada (glacial) occurs in a few centuries to about two millennia. In analysis of the Owens Lake ostracode data from several interglacial and glacial sequences, it was determined that the ostracode data (like the diatom data) also show rapid transitions from glacial to interglacial conditions. Staff presented technical discussion about freshwater lacustrine diatoms as proxies for past climate from Owens Lake to Yucca Mountain at

the USGS Project Planning Progress meeting on May 7. Staff also continued to collect ostracode data from the Las Vegas and Indian Springs Valley deposits for stable isotope analyses and continued work on ostracode morphological change through long Quaternary lake records in order to document within-species range changes that may enhance the paleoclimatic resolving power of the ostracode record.

In data synthesis and interpretation for the paleoclimate synthesis report, staff continued work on a manuscript that treats the climatic and hydrological states that existed in the Las Vegas and Indian Springs Valleys during the Pleistocene in support of milestone SPC332M4. A paper titled *Reliable Late-Pleistocene stratigraphic ages and shorter ground-water travel times from ^{14}C in fossil snails from the southern Great Basin*, by R. Brennan and J. Quade, was recently published in *Quaternary Research*. This paper is also a partial fulfillment of milestone SPC332M4.

Brennan, R., and Quade, J., 1997, *Reliable Late-Pleistocene stratigraphic ages and shorter ground-water travel times from ^{14}C in fossil snails from the southern Great Basin*, *Quaternary Research*, v. 47, p. 329-336.

Staff participated in a field trip to show new NWTRB board members paleontological evidence for rise in the water-table along the Yucca Mountain ground-water flow gradient. Discussions included past and possible future climate change.

Evaluation of ground-water paleodischarge continued during the period. Staff completed preparation, chemical analyses, and U and Th isotope analyses from multiple subsamples of carbonate-silica rinds on Fortymile Wash alluvial clasts from two units associated with the high terrace at the Sever Wash goosenecks. The uppermost horizon is associated with the ultimate episode of alluvial aggradation, whereas the lower soil is associated with the former surface associated with the penultimate depositional cycle. Ages ($^{230}\text{Th}/\text{U}$) of about 70 to 30 ka and 170 to 150 ka were obtained from the upper and lower horizons, respectively. Data were collected as part of an effort to understand how the alluvial history of Fortymile Wash is related to changing climate and the ground-water history expressed at discharge sites to the south.

Staff completed revisions to a manuscript titled *Late Quaternary history of Fortymile Wash, southern Great Basin, Nevada and California*. The paper presents new $^{230}\text{Th}/\text{U}$ and thermoluminescence geochronological data for surface deposits associated with Pleistocene alluvial activity and interprets these data as a surface-water and ground-water response to changing climatic history in the Yucca Mountain vicinity. The manuscript is being prepared for submission to an outside peer-reviewed technical journal, the *Geological Society of America Bulletin*.

Various banded travertine veins exposed in the Specter Range east of Yucca Mountain were examined as evidence of possible elevated regional ground-water levels during past pluvial intervals. In addition, areas above present-day discharging elevations at Point of Rock Springs and Longstreet Spring at Ash Meadows were examined.

USGS staff organized and lead a field trip and discussion at the request of NWTRB members D. Parizek, J. Wong, and F. Capparisio, along with L. Reiter (NWTRB staff), V. Palciauskas

(NWTRB staff), and S. Morris, T. Sullivan, and R. Patterson (DOE). The trip was intended to describe work and results from past-discharge sites and their relation to the current, steady-state regional ground-water flow model. Sites visited included Lathrop Wells diatomite (Highway 95 whitebeds), Stateline deposits, Ash Meadows, Franklin Lake Playa, and Travertine Point along Furnace Creek. Several of the sites were revisited with additional DOE participants the following day, after the NWTRB had departed.

Studies of past water flux and of fracture-fill materials in the ESF continued. Staff prepared an oral presentation titled *U-Pb dating of ^{234}U -enriched Quaternary opal microsamples, Yucca Mountain, Nevada, USA* (by L.A. Neymark, Yu V. Amelin, and J.B. Paces) which was delivered at the annual meeting of the Geological Association of Canada/Mineral Association of Canada in Ottawa, Ontario. The published reference is:

Neymark, L.A., Amelin, Y. V., and Paces, J.B., 1997, *U-Pb dating of ^{234}U -enriched Quaternary opal microsamples, Yucca Mountain, Nevada, USA* (abst): Proceedings of the Geological Association of Canada/Mineralogical Association of Canada Annual Meeting, Ottawa., p. A-108.

A first-draft manuscript describing analytical work done on subsurface mineral deposits at Yucca Mountain and interpretations of data using a model of slow, continuous mineral growth was completed. The manuscript includes analytical solutions of a continuous-deposition model that allows determinations of ages and initial $^{234}\text{U}/^{238}\text{U}$ ratios from measured data. The working title of the manuscript is *Mixed $^{230}\text{Th}/\text{U}$ ages for subsurface secondary opal resulting from slow rates of deposition, Yucca Mountain, Nevada* by L.A. Neymark and J.B. Paces. The manuscript is being prepared for submission to the peer-reviewed technical journal *Earth and Planetary Science Letters*.

Analytical efforts continued. Seven subsamples were prepared from a 1-cm-thick mineral coating taken in the ESF south ramp at station 75+07. The series of samples represents an internal stratigraphic sequence of massive silica layers and outermost opal, and samples will be submitted for dating by U-Pb and U-series techniques. Staff described secondary minerals from occurrences in the ESF south ramp and from SD-9 core. Subsamples from these occurrences were prepared and will be submitted for ^{18}O and ^{13}C analyses. Revisions to technical procedure GCP-26 [Determination of the Isotopic Ratio $^{18}\text{O}/^{16}\text{O}$ in H_2O] were completed and sent for technical and QA review. Polished thick sections were documented with photography and sent for fluid-inclusion study.

Staff worked on a manuscript titled *Origins and paleohydrologic implications of secondary calcite and silica minerals in Tertiary tuffs, Yucca Mountain, Nevada* describing interpretations and physical and stable isotope results obtained from ESF and borehole occurrences. The manuscript is intended for submission to the outside peer-reviewed technical journal, Geological Society of America *Bulletin*.

Minor revisions were made to *Applications of isotope geochemistry to the reconstruction of Yucca Mountain paleohydrology* and *Origin and paleoclimatic implications of secondary calcite beneath Yucca Mountain: Review, provisional results, and goals of ongoing data collection*, the

FY96 and FY95 level 3 milestone reports of the Calcite and Opaline Silica Studies project, in preparation for their publication as open-file reports.

Staff prepared an oral presentation titled *Strontium isotopes in pore water from the unsaturated zone at Yucca Mountain, Nevada*, by B. Marshall, K. Futa and Z. Peterman. The paper describes Sr isotopic analyses of leachates from SD-7 crushed core and preliminary interpretations with regard to matrix versus fracture flow within the UZ. The presentation will be made at the Seventh Annual V.M. Goldschmidt Conference in Tucson, Arizona, in early June, and the abstract will be published in the meeting proceedings.

Samples of secondary surface materials were collected at and adjacent to the SD-7 drill pad at Yucca Mountain. Both bedrock coatings and calcrete were collected. These materials represent the local surface sources for Sr entering the subsurface in infiltrating solutions.

Chemical and Sr isotopic analysis of approximately 10 subsamples of carbonate-rich surface materials sampled from the SD-7 vicinity were completed. These analyses represent the primary reservoir of Sr available to soil-zone solutions infiltrating the subsurface near the crest of Yucca Mountain. All $^{87}\text{Sr}/^{86}\text{Sr}$ analyses are within the range of the pore-water leach values from the Tiva Canyon Tuff but are substantially lower than the values observed within the PTn and underlying Topopah Spring Tuff in the SD-7 section. Therefore, an additional source of higher $^{87}\text{Sr}/^{86}\text{Sr}$ is necessary to explain observed isotopic compositions in the units underlying the Tiva Canyon Tuff.

Initial samples of opal bubbles from lithophysal cavity occurrences were prepared for reconnaissance $^{230}\text{Th}/\text{U}$ dating using laser ablation and ICP-MS (inductively-coupled plasma mass spectrometry). If successful, the technique would allow age analysis from a spot approximately 10 to 20 microns in diameter. Although micron-scale layers are not individually resolvable using a laser beam of this size, the validity of models involving very slow but continuous mineral deposition can be tested assuming adequate ^{230}Th is obtained.

WBS 1.2.3.9 SPECIAL STUDIES

Work continued on the PISA synthesis reports. Drafts for each USGS section of the geological systems description (PISA chapter 2.3) and the unified reference section were submitted to the TPO thereby meeting six level 4 milestones. Submitted sections included section 2.3.1 - Regional Geologic Setting (which incorporates milestones SPG39BM4 [Structural geology and regional tectonics] and SPG39DM4 [Regional stratigraphy]), section 2.3.2 - Tectonic Models (which incorporates milestones SPG39BM4 and SPG39FM4 [Structural geology and site-scale tectonics]), section 2.3.4 - Seismicity and Seismic Hazards (which combines milestones SPG39AM4 [Regional seismology] and SPG39EM4 [Seismology of the site]), section 2.3.6 - Site Stratigraphy (milestone SPG39CM4 [Site stratigraphy]), and section 2.3.7 - Site Structural Geology (milestone SPD39FM4 [Structural geology and site-scale tectonics]). The combined reference section (81 pages) contains the Yucca Mountain Accession and/or Data Tracking Numbers (where such information was available) as well as the Q status of reports of

data.

Work continued on the PISA hydrology chapter with teleconferences regarding inclusion of topics and wording into the hydrology chapter to support later regulatory-compliance analyses. The Principal Investigator (hydrology) met with contributing authors to evaluate input for the SZ description. A progress review of UZ data-collection sections was held on May 20. Sections on infiltration and UZ rock-matrix properties are progressing on schedule. The PI and the contributing author for the UZ infiltration section attended the PISA Climate chapter planning meeting in Denver on May 21. The main purpose was to coordinate with climate authors regarding the meteorology content needed to support discussions of infiltration in the hydrology chapter. A secondary purpose was to initiate coordination between paleoclimatic and paleohydrologic discussions in the two chapters.

Specific work on the PISA climate/meteorological site description (chapter 3.4) continued with a meeting in Denver on May 21 to discuss the general content of the various subchapters. Draft outlines of the various subchapters were also prepared and distributed.

The USGS technical lead for the Site Characterization Progress Report (SCPR) fielded about 20 significant technical comments that arose from the internal M&O/USGS review of SCPR #16. The comments were divided between Rock Characteristics and Geohydrology/Climate. Comments on the Rock Characteristics section included the QA status of borehole geophysical logs, comparison of QA'd and non-Q fracture data, hanging-wall deformation along the Ghost Dance Fault, "relay" faults, the relation between volcanism and seismicity in postclosure tectonics models, and the earthquake catalog developed to support the probabilistic seismic hazard analysis (PSHA). Comments on the Geohydrology and Climate sections addressed infiltration and recharge rates at Yucca Mountain, saturated matrix-properties samples from the ESF, pneumatic-pressure monitoring for confirmation of perched-water zones, water potentials in the PTn in the south ramp of the ESF, CO₂ content of rock gas, source and age of UZ pore water based on deuterium data, confidence intervals for tritium data collected from the northern Ghost Dance fault alcove in the ESF, ¹⁴C age corrections for perched water and UZ pore water, and the ²³⁴U/²³⁸U model for indicating percolation flux in the UZ. About half of the comments were resolved by the technical lead without input from investigators. Remaining comments required explanations from the nine investigators who had collected and/or analyzed the data in question.

The technical lead for the SCPR also assisted M&O staff in the resolution of several major technical issues discussed in the Executive Summary of SCPR #16. These issues included infiltration rates used in process-level and performance-assessment models, current status of the site-scale UZ transport model, and estimates of percolation flux at the repository horizon. The technical lead also submitted to the M&O SCPR coordinator 20 references not cited in previous SCPRs.

The technical lead for the SCPR assisted M&O staff in compiling technical references that describe various field methods for collection of hydrogeologic data at Yucca Mountain. The references were requested to support the draft description of monitoring activities for the Performance Confirmation initiative.

WBS 1.2.8.4.7 WATER-RESOURCES MONITORING

Ground-water monitoring efforts continued during the period. Staff obtained USGS-YMPB approval of technical procedures for collection and analysis of ground-water samples. Water samples for the M&O's Radiological/Environmental Field Programs were collected during the period from May 5 to May 16 to characterize ground water with respect to drinking-water standards. Review of preliminary laboratory analyses was initiated.

Ground-water levels were measured at 29 sites, and ground-water discharge was measured at five springs and one flowing well. Staff assisted with preparations for water-quality sampling and collection of water-quality samples during the weeks of May 5 and 12 (in support of Environmental Program efforts to characterize regional ground-water quality and the M&O's Radiological/Environmental Field Programs). USGS staff discussed inconsistencies in the NWIS database (following merge of the USGS-NV District and USGS-ESIP databases) with USGS-NV District data-management personnel; data-management personnel began correcting the NWIS database. Environmental personnel plan to measure water levels, during the remainder of FY 1997, at four sites in Jackass Flats that were previously measured as part of the Site-Characterization Program (to satisfy requirements of the water-appropriations permit).

Processing and checking of water-level and discharge data collected and compiled during calendar year 1996 was completed, including compilation and checking of water-use data for the region. Preparation of the data package for submittal to colleague review was begun.

USGS Level 3 Milestone Report

October 1, 1996 - May 31, 1997

Sorted by Baseline Date

<u>Deliverable</u>	<u>Due Date</u>	<u>Expected Date</u>	<u>Completed Date</u>	<u>Comments</u>
LETTER REPORT Milestone Number: SSH13BM3	11/1/96	10/30/96	10/30/96	
LETTER REPORT Milestone Number: SSH13CM3	1/31/97	1/30/97	1/30/97	
Ltr Rpt: Geo S.R. Sta 55+00 to STA 63+47 Milestone Number: SPG42BM3	2/28/97	2/27/97	2/27/97	
Rpt Geo North/South Main Drft Sta 28+00 to 55+00 Milestone Number: SPG42AM3	2/28/97	2/28/97	2/28/97	
Main Drift Hydrogeology Report Milestone Number: SPH223M3	3/14/97	3/14/97	3/14/97	
Initiate South GDF Testing Geothermal Borehole Milestone Number: SP3505M3	4/18/97	4/10/97	4/10/97	
Complete Fracture Evaluation Report Milestone Number: SPG32M3	4/30/97	4/29/97	4/29/97	
LETTER REPORT Milestone Number: SSH13DM3	5/1/97	4/29/97	4/29/97	
Initiate North Gdf Alcove Testing Milestone Number: SP3500M3	5/16/97	5/15/97	5/15/97	

USGS Level 4 Milestone Report

October 1, 1996 - May 31, 1997

Sorted by Baseline Date

<u>Deliverable</u>	<u>Due Date</u>	<u>Expected Date</u>	<u>Completed Date</u>	<u>Comments</u>
Memo to TPO: SS Hazards Methodologies Wrkshop Milestone Number: SPG28FM4	10/25/96	10/24/96	10/24/96	
Memo to TPO: Jan-Jun96 Perio Wtr Lvl Data to RPC Milestone Number: SPH21CM4	10/31/96	10/30/96	10/30/96	
Memo to TPO: SS Hazards Method. Wrkshop Summary Milestone Number: SPG28GM4	11/15/96	11/14/96	11/14/96	
Memo to TPO: Seis. Src. Mdls & Proponents Wrkshop Milestone Number: SPG28HM4	11/27/96	11/26/96	11/26/96	
Memo to TPO: Comp Frac Data Coll: Cal. Hills, Prov Milestone Number: SPG34M4	11/27/96	11/27/96	11/27/96	
Memo to TPO: Comp Re-Eval Priority Strat Contact Milestone Number: SPG21M4	12/13/96	12/13/96	12/13/96	
Memo to TPO: Detailed Content Outline Milestone Number: SPH391M4	12/13/96	12/13/96	12/13/96	
Memo to TPO: SS Modls & Proponents Wrkshop Summry Milestone Number: SPG28IM4	12/19/96	12/19/96	12/19/96	
Report: Mod Flow In UZ Frac Ntwk TS W-U in ESF Milestone Number: SPH21AM4	12/31/96	12/19/96	12/19/96	
Memo to TPO: Monitoring Data Apr-Sep 1996 to RPC Milestone Number: SPH22GM4	12/31/96	12/23/96	12/23/96	
Memo to TPO: GM Models and Interpret. Workshop Milestone Number: SPG28AM4	1/17/97	1/13/97	1/13/97	
Memo to TPO: Seismic Source Interp. Wrkshop Milestone Number: SPG28JM4	1/17/97	1/13/97	1/13/97	

<u>Deliverable</u>	<u>Due Date</u>	<u>Expected Date</u>	<u>Completed Date</u>	<u>Comments</u>
Memo to TPO: Clim Scenarios Recvd & Sim Started Milestone Number: SPH23AM4	1/30/97	1/13/97	1/13/97	
Memo to TPO: SS Interpretations Wrkshp Summary Milestone Number: SPG28KM4	2/4/97	2/3/97	2/3/97	
Memo to TPO: GM Modls & Interpret Wrkshp Summry Milestone Number: SPG28BM4	2/6/97	2/5/97	2/5/97	
Memo to TPO: Sub Bh Video Frac Db to GENISES Milestone Number: SPG211M4	2/28/97	2/27/97	2/27/97	
Memo to TPO: Jul-Dec96 Perio Wtr Lvl Data to RPC Milestone Number: SPH21BM4	2/28/97	2/7/97	2/7/97	
Memo to TPO: Annotated Outline Site SZ Synth Rpt Milestone Number: SPH23VM4	2/28/97	2/11/97	2/11/97	
Memo to TPO: Summary of Meetings with PA Mdlrs Milestone Number: SPH25CM4	2/28/97	2/13/97	2/13/97	
Memo to TPO: Rsults New Age & Iso Determinations Milestone Number: SPC23FM4	3/14/97	3/14/97	3/14/97	
Memo to TPO: 1995 Water-Level Data Milestone Number: SPH21FM4	3/14/97	2/13/97	2/13/97	
Memo to TPO: Meteorological Data FY96 to RPC/TDB Milestone Number: SPH211M4	3/14/97	3/14/97	3/14/97	
Publish Sel Streamflow & Precip Data for FY96 Milestone Number: SPH22CM4	3/14/97	6/30/97		
Memo to TPO: Subm FY96 Data to RPC/TDB Milestone Number: SPH22DM4	3/14/97	3/14/97	3/14/97	
Memo to TPO: Trans Funct Precip/Infil of Num Mdl Milestone Number: SPH22FM4	3/14/97	3/11/97	3/11/97	
Memo to TPO: Synth UZ Mont Data fm MD of ESF Milestone Number: SPH221M4	3/14/97	3/14/97	3/14/97	

<u>Deliverable</u>	<u>Due Date</u>	<u>Expected Date</u>	<u>Completed Date</u>	<u>Comments</u>
Memo to TPO: Reslt of Matrix-Hydro-Prop Determin Milestone Number: SPH22KM4	3/14/97	3/11/97	3/11/97	
Memo to TPO: Matrix-Hydro-Prop Compl Pkg to RPC Milestone Number: SPH22LM4	3/14/97	3/11/97	3/11/97	
Memo to TPO: Monitoring Data Thru Jan 97 to RPC Milestone Number: SPH22NM4	3/14/97	3/7/97	3/7/97	
Memo to TPO: Rslts Analyses/Interpret thru Jan97 Milestone Number: SPH22QM4	3/14/97	3/11/97	3/11/97	
Memo to TPO: Data Collected thru Jan 97 to RPC Milestone Number: SPH22RM4	3/14/97	3/14/97	3/14/97	
Memo to TPO: Rslts Chem Analysis Thru Jan 1997 Milestone Number: SPH22WM4	3/14/97	3/10/97	3/10/97	
Memo to TPO: Pkg of Chem Anal thru Jan 97 to RPC Milestone Number: SPH22XM4	3/14/97	3/14/97	3/14/97	
Memo to TPO: Final Hydrogeo Framewrk Data to RPC Milestone Number: SPH23DM4	3/14/97	3/14/97	3/14/97	
Memo to TPO: Test Data for July-Dec 1996 to RPC Milestone Number: SPH23MM4	3/14/97	3/14/97	3/14/97	
Memo to TPO: Results of Tests Comp Jul-Dec 96 Milestone Number: SPII23NM4	3/14/97	3/14/97	3/14/97	
Memo to TPO: Tech Anal/Interp Air-Perm & Hydroch Milestone Number: SPH35EM4	3/14/97	3/13/97	3/13/97	
Memo to TPO: Subm Air-Perm/Hydrochem Tstg to RPC Milestone Number: SPH35FM4	3/14/97	3/14/97	3/14/97	
Memo to TPO:Elicit of Experts Interpret Complete Milestone Number: SPG28LM4	3/20/97	3/20/97	3/20/97	
Memo to TPO: Comp QA Eval pre-1992 Bh Geo Logs Milestone Number: SPG212M4	3/28/97	3/26/97	3/26/97	

<u>Deliverable</u>	<u>Due Date</u>	<u>Expected Date</u>	<u>Completed Date</u>	<u>Comments</u>
Memo to TPO: Draft Site Area Geol. Map to PISA Milestone Number: SPG222M4	4/18/97	4/17/97	4/17/97	
Memo to TPO: Ground Motion Feedback Workshop Milestone Number: SPG28CM4	4/21/97	4/21/97	4/21/97	
Memo to TPO: Seismic Source Feedback Workshop Milestone Number: SPG28MM4	4/25/97	4/21/97	4/21/97	
Memo to TPO: Updated Geohydro Frmwrk Sub for Rev Milestone Number: SPH24FM4	4/30/97	4/29/97	4/29/97	
Memo to TPO: Rev Dft Reg SZ Synth Rpt Clim Chng Milestone Number: SPH23BM4	5/1/97	5/1/97	5/1/97	
Memo to TPO: GM Feedback Workshop Summary Milestone Number: SPG28DM4	5/13/97	5/13/97	5/13/97	
Memo to TPO: SS Feedback Workshop Summary Milestone Number: SPG28NM4	5/19/97	5/19/97	5/19/97	
Memo to TPO: Regional Seismology Milestone Number: SPG39AM4	5/29/97	5/29/97	5/29/97	
Memo to TPO: Regional Struct Geology & Tectonics Milestone Number: SPG39BM4	5/29/97	5/29/97	5/29/97	
memo to TPO: Site Stratigraphy Milestone Number: SPG39CM4	5/29/97	5/29/97	5/29/97	
Memo to TPO: Regional Stratigraphy Milestone Number: SPG39DM4	5/29/97	5/29/97	5/29/97	
Memo to TPO: Site Seismology Milestone Number: SPG39EM4	5/29/97	5/29/97	5/29/97	
Memo to TPO: Site Struct Geology and Tectonics Milestone Number: SPG39FM4	5/29/97	5/29/97	5/29/97	
Memo to TPO: Rev Draft Site SZ Synthesis Report Milestone Number: SPH23WM4	5/30/97	6/23/97		

WBS No. - 1.2 WBS Title - Yucca Mountain Project Parent WBS No. - 1.0 Parent WBS Title - Mined Geologic Disposal System	Element ID - 12
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Statement of Work:

See the current WBS Dictionary

		Cost/Schedule Performance													
		Current Period					FY1997 Cumulative to Date					FY1997 at Completion			
Id	Description	BCWS	BCWP	ACWP	SV	CV	BCWS	BCWP	ACWP	SV	CV	BAC	EAC	VAC	
1.2.3	Site Investigations	973	973	1074	0	-101	7605	7871	7648	266	223	11402	12689	-1287	
1.2.5	Regulatory	50	50	49	0	1	318	318	272	0	46	504	496	8	
1.2.8	Environment, Safety, and H	50	50	49	0	1	406	406	389	0	17	612	701	-89	
1.2.9	Project Management	53	53	56	0	-3	419	419	382	0	37	664	627	37	
1.2.12	Information Management	6	6	5	0	1	52	52	33	0	19	80	71	9	
1.2.15	Support Services	147	147	141	0	6	1148	1148	1086	0	62	1722	1723	-1	
Total		1279	1279	1374	0	-95	9948	10214	9810	266	404	14984	16307	-1323	

Resource Distributions by Element of Cost

Fiscal Year 1997

Budgeted Cost of Work Scheduled

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
LBRHRS	19540	19599	16166	20824	21329	20182	22106	22047	22573	22479	21615	20362	248822
LABOR	885	899	632	866	876	906	909	904	921	919	891	856	10464
SUBS	139	143	87	148	145	145	140	150	153	149	148	136	1683
TRAVEL	25	43	34	45	43	47	35	37	38	36	35	31	449
PM&E	7	6	7	5	9	6	7	6	9	7	5	4	78
OTHER	197	201	179	206	285	184	178	182	176	179	170	173	2310
Total BCWS	1253	1292	939	1270	1358	1288	1269	1279	1297	1290	1249	1200	14984

Actual Cost of Work Performed

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
LBRHRS	19283	18578	18523	18723	17133	18725	19233	19288	0	0	0	0	149486
LABOR	771	712	732	829	727	782	788	826	0	0	0	0	6167
SUBS	127	139	117	185	134	179	226	134	0	0	0	0	1241
TRAVEL	11	24	61	53	42	46	44	57	0	0	0	0	338
PM&E	43	16	88	85	89	110	60	192	0	0	0	0	683
OTHER	119	129	145	158	252	239	174	165	0	0	0	0	1381
Total ACWP	1071	1020	1143	1310	1244	1356	1292	1374	0	0	0	0	9810

WBS No.

- 1.2

-Yucca Mountain Project

Resource Distributions by Element of Cost

Fiscal Year 1997

Estimate to Complete

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
LBRHRS	0	0	0	0	0	0	0	0	24520	24428	23302	22005	94255
LABOR	0	0	0	0	0	0	0	0	1026	1019	998	932	3975
SUBS	0	0	0	0	0	0	0	0	210	212	196	170	788
TRAVEL	0	0	0	0	0	0	0	0	59	59	66	52	236
PM&E	0	0	0	0	0	0	0	0	9	14	17	27	67
OTHER	0	0	0	0	0	0	0	0	308	243	400	480	1431
Total ETC	0	0	0	0	0	0	0	0	1612	1547	1677	1661	6497

Resource Distributions

Fiscal Year 1997	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
BCWS	1253	1292	939	1270	1358	1288	1269	1279	1297	1290	1249	1200	14984
BCWP	1195	1245	1131	1353	1328	1338	1345	1279	0	0	0	0	10214
ACWP	1071	1020	1143	1310	1244	1356	1292	1374	0	0	0	0	9810
ETC	0	0	0	0	0	0	0	0	1612	1547	1677	1661	6497

Fiscal Year Distribution

[illegible]

YMP PLANNING AND CONTROL SYSTEM (PACS)

Participant U.S. Geological Survey
 Date Prepared 06/11/97 08:00

MONTHLY COST/FTE REPORT

Fiscal Month/Year MAY 1997
 Page 1 of 1

WBS ELEMENT	<u>CURRENT MONTH END</u>			<u>FISCAL YEAR</u>					
	ACTUAL COSTS	PARTICIPANT HOURS	SUBCON HOURS	PURCHASE COMMITMENTS	SUBCON COMMITMENTS	ACCRUED COSTS	APPROVED BUDGET	APPROVED FUNDS	CUMMULATIVE COSTS
1.2.3	1070	16097	4048	0	746	91	12260	10218	7617
1.2.5	49	352	800	0	104	0	504	437	270
1.2.8	49	556	0	0	0	0	612	542	389
1.2.9	55	888	240	0	41	11	664	584	383
1.2.12	5	176	0	0	0	6	80	70	33
1.2.15	138	1219	0	52	42	33	1722	1526	1070
TOTALS	1366	19288	5088	52	933	141	15842	13377	9762

U.S. GEOLOGICAL SURVEY
ESTIMATED COSTS FOR 10/1/96 - 05/31/97

	OCT EST	NOV EST	DEC EST	JAN EST	FEB EST	MAR EST	APR EST	MAY EST	JUN EST	JUL EST	AUG EST	SEP EST	TOTAL
OG311FA1 Scientific Programs Management & Integra	15.7	16.6	12.0	21.8	62.3	32.4	35.6	28.3	0.0	0.0	0.0	0.0	224.7
1.2.3.1.1	15.7	16.6	12.0	21.8	62.3	32.4	35.6	28.3	0.0	0.0	0.0	0.0	224.7
OG312FA1 Nevada Operations/Earth Science Investig	55.0	57.4	62.9	66.3	98.9	87.7	57.2	46.4	0.0	0.0	0.0	0.0	531.8
1.2.3.1.2	55.0	57.4	62.9	66.3	98.9	87.7	57.2	46.4	0.0	0.0	0.0	0.0	531.8
*1.2.3.1	70.7	74.0	74.9	88.1	161.2	120.1	92.8	74.7	0.0	0.0	0.0	0.0	756.5
OG32211FB1 Review & Revision of Lithostratigraphy B	14.1	13.4	50.3	23.9	8.6	14.0	2.4	6.6	0.0	0.0	0.0	0.0	133.3
1.2.3.2.2.1.1	14.1	13.4	50.3	23.9	8.6	14.0	2.4	6.6	0.0	0.0	0.0	0.0	133.3
OG32212FB2 Complete Site Area Geologic Map	36.9	24.9	34.2	12.0	21.2	50.7	18.6	25.8	0.0	0.0	0.0	0.0	277.7
OG32212FB3 Fracture Studies	6.3	16.8	14.9	12.2	9.9	9.7	10.8	5.7	0.0	0.0	0.0	0.0	97.0
OG32212FB4 Geologic Mapping of the Exploratory Stud	119.7	139.2	106.3	155.8	135.2	146.7	148.2	124.8	0.0	0.0	0.0	0.0	1075.9
1.2.3.2.2.1.2	162.9	180.9	155.4	180.0	166.3	207.1	177.6	156.3	0.0	0.0	0.0	0.0	1386.5
OG3252FB1 Evaluate Tectonic Scenarios for PA	10.6	4.1	-4.1	2.3	0.0	2.5	0.6	0.1	0.0	0.0	0.0	0.0	16.1
1.2.3.2.5.2	10.6	4.1	-4.1	2.3	0.0	2.5	0.6	0.1	0.0	0.0	0.0	0.0	16.1
OG32836FB1 Conduct Probabilistic Seismic Hazards An	88.3	62.1	54.3	46.4	36.5	3.0	53.5	47.4	0.0	0.0	0.0	0.0	391.5
1.2.3.2.8.3.6	88.3	62.1	54.3	46.4	36.5	3.0	53.5	47.4	0.0	0.0	0.0	0.0	391.5
*1.2.3.2	275.9	260.5	255.9	252.6	211.4	226.6	234.1	210.4	0.0	0.0	0.0	0.0	1927.4
OG33111FB4 Collection of Site Meteor. Data for Hydr	7.8	8.8	12.2	17.5	14.3	29.6	0.4	5.9	0.0	0.0	0.0	0.0	96.5
1.2.3.3.1.1.1	7.8	8.8	12.2	17.5	14.3	29.6	0.4	5.9	0.0	0.0	0.0	0.0	96.5
OG33112FB1 Collection of Site Streamflow Data	5.6	5.1	5.3	7.4	5.7	7.1	0.0	0.0	0.0	0.0	0.0	0.0	36.2
OG33112FB2 Collection of Site Streamflow Data	0.0	0.0	0.0	0.0	0.0	0.0	6.8	6.0	0.0	0.0	0.0	0.0	12.8
1.2.3.3.1.1.2	5.6	5.1	5.3	7.4	5.7	7.1	6.8	6.0	0.0	0.0	0.0	0.0	49.0
OG33114FB3 Regional Saturated Zone Synthesis Report	7.6	7.6	0.0	12.5	29.1	11.6	55.4	15.7	0.0	0.0	0.0	0.0	139.5
1.2.3.3.1.1.4	7.6	7.6	0.0	12.5	29.1	11.6	55.4	15.7	0.0	0.0	0.0	0.0	139.5
OG33121FB1 Infiltration Processes	21.5	16.0	19.0	18.3	30.7	41.4	6.1	-6.8	0.0	0.0	0.0	0.0	146.2
1.2.3.3.1.2.1	21.5	16.0	19.0	18.3	30.7	41.4	6.1	-6.8	0.0	0.0	0.0	0.0	146.2
OG33123FB4 Integrated Analysis & Interpretation	14.5	5.4	14.5	20.9	38.8	10.6	-14.8	-0.2	0.0	0.0	0.0	0.0	89.7
OG33123FB5 Matrix Properties of Hydrologic Units	14.1	12.0	16.2	17.8	1.8	3.7	4.9	0.4	0.0	0.0	0.0	0.0	70.9
OG33123FBA Unsaturated Zone Borehole Instrumentatio	31.9	36.3	32.6	32.3	34.2	-10.8	1.5	0.0	0.0	0.0	0.0	0.0	158.0
OG33123FBB Unsaturated Zone Borehole Instrumentatio	0.0	0.0	0.0	0.0	0.0	11.0	24.4	21.5	0.0	0.0	0.0	0.0	56.9
OG33123FBC Integrated Analysis & Interpretation	0.0	0.0	0.0	0.0	0.0	9.3	32.9	13.6	0.0	0.0	0.0	0.0	55.8
OG33123FBD Matrix Properties of Hydrologic Units	0.0	0.0	0.0	0.0	0.0	0.0	16.5	15.6	0.0	0.0	0.0	0.0	32.1
1.2.3.3.1.2.3	60.5	53.7	63.3	71.0	74.8	23.8	65.4	50.9	0.0	0.0	0.0	0.0	463.4
OG33124E96 Air-K and Hydrochemisty Test - North Ram	5.5	3.1	6.4	6.1	1.4	5.8	0.1	0.0	0.0	0.0	0.0	0.0	28.4
OG33124FA1 Support E&I Design Basis Modeling	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.0	2.1
OG33124FB7 Air Permeability & Hydrochem Testing ESF	46.1	40.6	40.9	68.9	62.7	21.6	-5.9	10.8	0.0	0.0	0.0	0.0	285.7
OG33124FB8 Percolation Flux across Repository Horiz	0.0	0.0	0.0	0.0	0.0	3.9	1.8	-0.9	0.0	0.0	0.0	0.0	4.8
OG33124FBA Moisture Monitoring in the ESF	2.4	2.4	1.5	18.3	8.3	2.6	2.2	1.9	0.0	0.0	0.0	0.0	39.6

U.S. GEOLOGICAL SURVEY
ESTIMATED COSTS FOR 10/1/96 - 05/31/97

	OCT EST	NOV EST	DEC EST	JAN EST	FEB EST	MAR EST	APR EST	MAY EST	JUN EST	JUL EST	AUG EST	SEP EST	TOTAL
OG33124FBB Air-Permeability & Hydrochem Testing ESF	0.0	0.0	0.0	0.0	0.0	14.5	56.6	62.1	0.0	0.0	0.0	0.0	133.2
OG33124FBD Moisture Monitoring in the ESF	0.0	0.0	0.0	0.0	0.0	4.9	18.8	16.7	0.0	0.0	0.0	0.0	40.4
OG33124FBF South Ramp Hydrology	0.0	0.0	0.0	0.0	0.0	44.3	18.1	80.2	0.0	0.0	0.0	0.0	142.6
OG33124FBG PIn Lateral Diversion (Phase I)	0.0	0.0	0.0	0.0	0.0	2.0	8.5	3.9	0.0	0.0	0.0	0.0	14.4
OG33124FBH ESF Drift Scale Flux and Niche Study	0.0	0.0	0.0	0.0	0.0	2.0	10.8	8.8	0.0	0.0	0.0	0.0	21.6
1.2.3.3.1.2.4	54.0	46.1	48.8	93.3	72.4	101.6	111.0	185.6	0.0	0.0	0.0	0.0	712.8
OG33127B96 UZ Hydrochemistry	0.0	0.0	0.0	20.0	0.0	0.4	3.1	3.6	0.0	0.0	0.0	0.0	27.1
OG33127FBA UZ Hydrochemistry	23.0	27.1	22.0	1.2	18.0	14.5	-14.3	-2.3	0.0	0.0	0.0	0.0	8
OG33127FBB UZ Hydrochemistry	0.0	0.0	0.0	0.0	0.0	12.8	29.7	25.0	0.0	0.0	0.0	0.0	6
1.2.3.3.1.2.7	23.0	27.1	22.0	21.2	18.0	27.7	18.5	26.3	0.0	0.0	0.0	0.0	183.8
OG33128FBD Fluid Flow in Unsaturated Zone Fractured	7.6	5.3	2.9	6.0	4.8	2.0	-0.4	0.0	0.0	0.0	0.0	0.0	28.2
1.2.3.3.1.2.8	7.6	5.3	2.9	6.0	4.8	2.0	-0.4	0.0	0.0	0.0	0.0	0.0	28.2
OG33129FBG Site Unsaturated Zone Flow Model	7.8	6.4	8.3	25.5	-13.3	10.9	-0.8	7.0	0.0	0.0	0.0	0.0	51.8
OG33129FBK Support UZ Model Expert Elicitation	0.0	21.2	6.8	8.6	7.4	3.5	3.2	0.3	0.0	0.0	0.0	0.0	51.0
1.2.3.3.1.2.9	7.8	27.6	15.1	34.1	-5.9	14.4	2.4	7.3	0.0	0.0	0.0	0.0	102.8
OG33131FBA C-Well Complex Hydraulic & Conservative	46.5	42.2	46.6	74.2	58.5	31.3	4.0	0.3	0.0	0.0	0.0	0.0	303.6
OG33131FBB C-Well Complex Hydraulic & Tracer Test	0.0	0.0	0.0	0.0	0.0	22.2	49.4	52.0	0.0	0.0	0.0	0.0	123.6
OG33131FBC Water-Level Monitoring	20.7	17.8	20.5	18.2	14.3	6.2	0.8	0.0	0.0	0.0	0.0	0.0	98.5
OG33131FBD Water-Level Monitoring	0.0	0.0	0.0	0.0	0.0	6.0	12.0	8.8	0.0	0.0	0.0	0.0	26.8
OG33131FBF WT Eh and Ph Measurements	0.0	0.0	0.0	0.0	0.0	0.0	2.3	2.7	0.0	0.0	0.0	0.0	5.0
1.2.3.3.1.3.1	67.2	60.0	67.1	92.4	72.8	65.7	68.5	63.8	0.0	0.0	0.0	0.0	557.5
OG33133FB3 Site Saturated Zone Flow Model	16.5	25.9	21.8	27.0	22.2	10.3	39.3	24.0	0.0	0.0	0.0	0.0	187.0
OG33133FB4 Site Saturated Zone Synthesis Report	1.3	0.0	2.5	0.3	11.0	6.2	10.4	23.6	0.0	0.0	0.0	0.0	55.3
OG33133FB5 Conduct VA SZ Flow Model Sensitivity An	4.0	2.0	2.6	8.5	8.9	12.9	22.0	16.2	0.0	0.0	0.0	0.0	77.1
OG33133FB6 Confirm SZ Hydrologic Flow Models	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
OG33133FB7 Support SZ Model Expert Elicitation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	1.2
1.2.3.3.1.3.3	21.8	27.9	26.9	35.8	42.1	29.4	71.7	65.0	0.0	0.0	0.0	0.0	320.6
*1.2.3.3	284.4	285.2	282.6	409.5	358.8	354.3	405.8	419.7	0.0	0.0	0.0	0.0	2800.3
OG3521FA1 Tracer Gas Support	5.7	5.1	6.0	6.8	5.4	9.5	6.4	2.9	0.0	0.0	0.0	0.0	47.8
1.2.3.5.2.1	5.7	5.1	6.0	6.8	5.4	9.5	6.4	2.9	0.0	0.0	0.0	0.0	47.8
*1.2.3.5	5.7	5.1	6.0	6.8	5.4	9.5	6.4	2.9	0.0	0.0	0.0	0.0	47.8
OG36212FB1 Confirmatory Aquatic Investigations	0.0	2.1	6.9	7.9	3.0	4.1	7.2	0.0	0.0	0.0	0.0	0.0	31.2
1.2.3.6.2.1.2	0.0	2.1	6.9	7.9	3.0	4.1	7.2	0.0	0.0	0.0	0.0	0.0	31.2
OG36215FB2 Paleoclimate/Paleoenvironmental Synthesi	40.1	38.6	31.7	62.4	37.8	19.5	9.6	30.1	0.0	0.0	0.0	0.0	269.8
1.2.3.6.2.1.5	40.1	38.6	31.7	62.4	37.8	19.5	9.6	30.1	0.0	0.0	0.0	0.0	269.8
OG36221FB1 Evaluation of Paleo Ground-Water Dischar	17.4	15.4	27.9	28.8	13.0	9.9	-34.8	30.2	0.0	0.0	0.0	0.0	107.8
OG36221FB2 Geo. Fract. Fill Mater, ESF & Est Past W	57.0	39.2	87.6	70.6	85.8	107.1	10.0	7.6	0.0	0.0	0.0	0.0	464.9

U.S. GEOLOGICAL SURVEY
ESTIMATED COSTS FOR 10/1/96 - 05/31/97

	OCT EST	NOV EST	DEC EST	JAN EST	FEB EST	MAR EST	APR EST	MAY EST	JUN EST	JUL EST	AUG EST	SEP EST	TOTAL
OG36221FB3 Syn.Dist.&Anal Geochron. Age Dets Potent	0.0	0.0	0.0	0.0	0.0	24.4	66.4	73.0	0.0	0.0	0.0	0.0	163.8
1.2.3.6.2.2.1	74.4	54.6	115.5	99.4	98.8	141.4	41.6	110.8	0.0	0.0	0.0	0.0	736.5
*1.2.3.6	114.5	95.3	154.1	169.7	139.6	165.0	58.4	140.9	0.0	0.0	0.0	0.0	1037.5
OG395FB1 Update 3-D Geologic Model/Database	0.0	0.0	0.0	0.0	0.0	0.0	5.7	15.5	0.0	0.0	0.0	0.0	21.2
1.2.3.9.5	0.0	0.0	0.0	0.0	0.0	0.0	5.7	15.5	0.0	0.0	0.0	0.0	21.2
OG398FA1D Support Systems Engineering Reports & St	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OG398FA1F Data & Del Mgt., QA Compl, Oversight Sup,	14.6	13.0	13.3	10.9	15.1	26.8	22.2	22.9	0.0	0.0	0.0	0.0	138.8
OG398FB1 Support Development of PISA Ch 2.3 (Geol	30.1	29.7	43.9	50.1	55.5	50.1	69.2	69.3	0.0	0.0	0.0	0.0	397.0
OG398FB1C Provide Support to LA Plan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OG398FB1E Provide Input to SC Progress Report 16	9.9	11.0	10.9	5.6	13.1	9.1	9.5	10.0	0.0	0.0	0.0	0.0	79.1
OG398FB2 Develop PISA Chapter 2.4 (Hydrology)	11.6	12.5	33.0	31.0	43.5	54.0	54.8	68.4	0.0	0.0	0.0	0.0	308.8
OG398FB2E Provide Input to SC Progress Report 17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OG398FB4 Dev Climate/Meteorologic Sys Desc (PISA	0.0	0.0	0.0	0.0	0.0	16.1	51.3	35.3	0.0	0.0	0.0	0.0	102.7
1.2.3.9.11	66.2	66.2	101.1	97.6	127.2	156.1	207.0	205.9	0.0	0.0	0.0	0.0	1027.3
*1.2.3.9	66.2	66.2	101.1	97.6	127.2	156.1	212.7	221.4	0.0	0.0	0.0	0.0	1048.5
**1.2.3	817.4	786.3	874.6	1024.3	1003.6	1031.6	1010.2	1070.0	0.0	0.0	0.0	0.0	7618.0
OG535FA1 Provide FY97 Technical Data Base Input	21.3	18.0	18.0	40.7	25.5	29.9	30.5	38.0	0.0	0.0	0.0	0.0	221.9
1.2.5.3.5	21.3	18.0	18.0	40.7	25.5	29.9	30.5	38.0	0.0	0.0	0.0	0.0	221.9
*1.2.5.3	21.3	18.0	18.0	40.7	25.5	29.9	30.5	38.0	0.0	0.0	0.0	0.0	221.9
OG541FA2 Viability Assessment Scenarios Developme	0.0	0.0	0.0	3.5	0.0	0.0	-0.1	1.3	0.0	0.0	0.0	0.0	4.7
1.2.5.4.1	0.0	0.0	0.0	3.5	0.0	0.0	-0.1	1.3	0.0	0.0	0.0	0.0	4.7
OG544FA1 UZ Flow Model Abstractions for VA	0.0	0.0	5.5	1.3	5.2	8.3	0.0	5.3	0.0	0.0	0.0	0.0	25.6
OG544FA2 SZ Flow Model Abstractions for VA	0.0	0.0	7.1	-0.4	-0.4	1.6	5.2	4.8	0.0	0.0	0.0	0.0	17.9
1.2.5.4.4	0.0	0.0	12.6	0.9	4.8	9.9	5.2	10.1	0.0	0.0	0.0	0.0	43.5
*1.2.5.4	0.0	0.0	12.6	4.4	4.8	9.9	5.1	11.4	0.0	0.0	0.0	0.0	0.0
**1.2.5	21.3	18.0	30.6	45.1	30.3	39.8	35.6	49.4	0.0	0.0	0.0	0.0	200.0
OG825FA1 Federal Occupation Safety & Health	8.8	7.1	9.0	8.9	7.3	7.4	7.0	11.9	0.0	0.0	0.0	0.0	67.4
1.2.8.2.5	8.8	7.1	9.0	8.9	7.3	7.4	7.0	11.9	0.0	0.0	0.0	0.0	67.4
*1.2.8.2	8.8	7.1	9.0	8.9	7.3	7.4	7.0	11.9	0.0	0.0	0.0	0.0	67.4
OG845FA1 Radiation Protection	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
1.2.8.4.5	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
OG847FA1 Water Resources Envir Impact Stmt Suppor	0.0	0.0	0.0	0.0	2.4	2.8	0.0	0.2	0.0	0.0	0.0	0.0	5.4
OG847FA2 Red Water Quality Sample Collection	0.0	0.0	0.0	0.0	0.0	49.3	3.8	0.0	0.0	0.0	0.0	0.0	53.1
OG847FB1 Water Resources	30.4	29.6	30.3	48.3	17.0	37.6	32.8	36.7	0.0	0.0	0.0	0.0	262.7
1.2.8.4.7	30.4	29.6	30.3	48.3	19.4	89.7	36.6	36.9	0.0	0.0	0.0	0.0	321.2
*1.2.8.4	30.4	29.6	30.4	48.3	19.4	89.7	36.6	36.9	0.0	0.0	0.0	0.0	321.3
**1.2.8	39.2	36.7	39.4	57.2	26.7	97.1	43.6	48.8	0.0	0.0	0.0	0.0	388.7

U.S. GEOLOGICAL SURVEY
ESTIMATED COSTS FOR 10/1/96 - 05/31/97

	OCT EST	NOV EST	DEC EST	JAN EST	FEB EST	MAR EST	APR EST	MAY EST	JUN EST	JUL EST	AUG EST	SEP EST	TOTAL
OG912FA1 Participant Technical Project Office	25.0	23.2	27.3	25.9	29.0	22.2	24.1	42.8	0.0	0.0	0.0	0.0	219.5
1.2.9.1.2	25.0	23.2	27.3	25.9	29.0	22.2	24.1	42.8	0.0	0.0	0.0	0.0	219.5
*1.2.9.1	25.0	23.2	27.3	25.9	29.0	22.2	24.1	42.8	0.0	0.0	0.0	0.0	219.5
OG922FA1 Participant Project Control - USGS	21.4	18.6	18.1	20.5	17.5	19.9	34.8	12.5	0.0	0.0	0.0	0.0	163.3
1.2.9.2.2	21.4	18.6	18.1	20.5	17.5	19.9	34.8	12.5	0.0	0.0	0.0	0.0	163.3
*1.2.9.2	21.4	18.6	18.1	20.5	17.5	19.9	34.8	12.5	0.0	0.0	0.0	0.0	163.3
**1.2.9	46.4	41.8	45.4	46.4	46.5	42.1	58.9	55.3	0.0	0.0	0.0	0.0	382.8
OGC522FA1 Satellite Records Operations	3.8	3.5	4.7	4.2	4.2	3.9	4.0	4.8	0.0	0.0	0.0	0.0	33.1
1.2.12.5.2.2	3.8	3.5	4.7	4.2	4.2	3.9	4.0	4.8	0.0	0.0	0.0	0.0	33.1
*1.2.12.5	3.8	3.5	4.7	4.2	4.2	3.9	4.0	4.8	0.0	0.0	0.0	0.0	33.1
**1.2.12	3.8	3.5	4.7	4.2	4.2	3.9	4.0	4.8	0.0	0.0	0.0	0.0	33.1
OGF23FA1 Support/Personnel Services	32.4	28.7	35.4	25.6	22.5	27.7	25.9	35.2	0.0	0.0	0.0	0.0	233.4
OGF23FA2 Facilities Management - Space	61.7	61.7	61.7	61.7	61.7	61.7	64.0	59.3	0.0	0.0	0.0	0.0	493.5
OGF23FA3 Facilities Management - Computers/Phones	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	0.0	0.0	0.0	0.0	133.6
OGF23FA4 Facilities Management - Other	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	0.0	0.0	0.0	0.0	100.0
OGF23FA5 Procurement/Property Management - USGS	10.2	11.0	8.0	7.3	11.5	9.9	8.5	9.9	0.0	0.0	0.0	0.0	76.3
1.2.15.2.3	133.5	130.6	134.3	123.8	124.9	128.5	127.6	133.6	0.0	0.0	0.0	0.0	1036.8
*1.2.15.2	133.5	130.6	134.3	123.8	124.9	128.5	127.6	133.6	0.0	0.0	0.0	0.0	1036.8
OGF3FA1 USGS Training Support	4.5	4.2	3.7	4.8	4.2	4.2	3.8	4.6	0.0	0.0	0.0	0.0	34.0
1.2.15.3	4.5	4.2	3.7	4.8	4.2	4.2	3.8	4.6	0.0	0.0	0.0	0.0	34.0
*1.2.15.3	4.5	4.2	3.7	4.8	4.2	4.2	3.8	4.6	0.0	0.0	0.0	0.0	34.0
**1.2.15	138.0	134.8	138.0	128.6	129.1	132.7	131.4	138.2	0.0	0.0	0.0	0.0	1070.8
1.2 OPERATING	1066.1	1021.1	1132.7	1305.8	1240.4	1347.2	1283.7	1366.5	0.0	0.0	0.0	0.0	9763.5
CAPITAL EQUIPMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
GRAND TOTAL	1066.1	1021.1	1132.7	1305.8	1240.4	1347.2	1283.7	1366.5	0.0	0.0	0.0	0.0	9763.5
FTEs													
FEDERAL	112.7	108.9	108.0	109.3	99.7	109.6	112.6	113.0	0.0	0.0	0.0	0.0	
CONTRACT	17.0	17.8	19.2	26.5	22.1	25.9	29.0	29.6	0.0	0.0	0.0	0.0	
TOTAL	129.7	126.7	127.2	135.8	121.8	135.5	141.6	142.6	0.0	0.0	0.0	0.0	

* Fourth level WBS roll-up

** Third level WBS roll-up