

**U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
OFFICE OF QUALITY ASSURANCE**

AUDIT REPORT

OF

U.S. GEOLOGICAL SURVEY

YUCCA MOUNTAIN SITE, NEVADA, and DENVER, COLORADO

**AUDIT NUMBER YM-ARP-95-20
SEPTEMBER 6 THROUGH 14, 1995**

Prepared by:



Date:

10/19/95

**Kenneth O. Gilkerson
Audit Team Leader
Yucca Mountain Quality
Assurance Division**

Approved by:



Date:

12/27/95

**Donald G. Horton
Director
Office of Quality Assurance**

1.0 EXECUTIVE SUMMARY

As a result of the Performance-Based Quality Assurance (QA) Audit YM-ARP-95-20, the audit team determined that the U.S. Geological Survey (USGS) is satisfactorily implementing an effective QA program and process controls for data collection and reporting from the field, with the exceptions noted in this report. However, the audit team determined there is not satisfactory implementation of an effective QA program and process controls for Unsaturated Zone (UZ) Modeling.

The audit team identified five deficiencies during the audit that resulted in the issuance of one Corrective Action Request (CAR), three Deficiency Reports (DR), and one Performance Report (PR). CAR Yucca Mountain Quality Assurance Division (YMQAD) -95-C051 documents that in several respects the USGS did not properly ensure that their QA program was implemented by their subcontractor. DR YMQAD-95-D016 addressed lack of training for contractor personnel. DR YMQAD-95-D017 found classification of a report as unqualified when the work was required to be qualified. YMQAD-95-D018 concerned the incomplete scope of technical review of a report to ensure correctness. PR YMQAD-95-P015 addressed that certain calibration records did not document the company that actually performed the calibration. There were three deficiencies identified by the audit team and corrected prior to the post audit meeting. These conditions are described in Section 5.5.2 of this report. Additionally, there were three process improvement recommendations resulting from this audit which are detailed in Section 6.0 of this report.

The audit team determined that USGS personnel involved in the scope of this audit were competent, qualified professionals that developed good technical data. The team was impressed with the thoroughness of field notes and sound independent review of the field data; however, there were some problems related to adequately depicting this information in published reports. The team based these observations on its evaluation of four reports that were examined during the audit at the Yucca Mountain Site (YMS), Nevada, and in Denver, Colorado.

One caveat should be made regarding implementation of the USGS QA program. During the course of this audit, significant budget cuts were made primarily in the use of contractors. In some cases, such as the calibration activities and the QA records center, the functions were completely staffed by contractors. Because the turnover time was limited, the staffing of these functions may not immediately result in the same level of quality as before.

2.0 SCOPE

The limited scope audit was conducted to evaluate the effectiveness of USGS's controls for developing a UZ Model in accordance with the Quality Assurance Requirements and Description (QARD) document (DOE/RW-0333P, Revision 4), and the Site Characterization Study Plans for the modeling and supporting data studies.

The processes/end-products evaluated during the audit, in accordance with the approved audit plan, are as follows:

PROCESS /ACTIVITY/ OR END-PRODUCT

Based on scoping discussions with the USGS Technical Project Officer four reports resulting from the unsaturated zone studies were selected for evaluation:

1. Stratigraphic Relations and Hydrologic Properties of the Paintbrush Tuff Nonwelded (PTn) Hydrologic Unit, Yucca Mountain, Nevada
2. Fracture Character of the Paintbrush Tuff Nonwelded Hydrologic Unit, Yucca Mountain, Nevada
3. In Situ Borehole Instrumentation and Monitoring Data (October 25, 1994 through April 12, 1995) for USW NRG-7a and USW NRG-6, Yucca Mountain, Nye County, Nevada
4. Preliminary Development of the LBL/USGS Three-Dimensional Site-Scale Model of Yucca Mountain, Nevada

The performance based evaluation of process effectiveness and product acceptability was based on:

1. Satisfactory implementation of the critical process steps,
2. Use of trained and qualified personnel working effectively,
3. Documentation that substantiates the quality of the products, and
4. Acceptable results and adequate end products.

TECHNICAL AREAS

The audit of UZ Studies was a technical evaluation of the activities associated with the Work Breakdown Structure (WBS) codes listed below. Two were added to those specified in the audit plan to add to the breadth of the review and to include the resulting modeling efforts.

WBS:

1.2.3.2.2.1.1

1.2.3.2.2.1.2

1.2.3.3.1.2.3

1.2.3.3.1.2.9

Title:

Vertical and Lateral Distribution of Stratigraphic Units Within the Site Area

Structural Features Within the Site Area

Percolation in the UZ - Surface Based Testing

Site Unsaturated Zone Modeling and Synthesis

3.0 AUDIT TEAM AND OBSERVERS

The following is a list of audit team members, their assigned areas of responsibility, and observers:

<u>Name/Title/Organization</u>	<u>QA Program Requirements/ Processes or Products</u>
Kenneth Gilkerson, Audit Team Leader (ATL), (YMQAD)	Supplement III, Critical Process Steps, and Selected UZ Studies
Alan Rabe, ATL-in-Training, YMQAD	Supplement III, Critical Process Steps, and Selected UZ Studies
James Blaylock, Auditor, YMQAD	Supplement III, Critical Process Steps, and Selected UZ Studies
Ralph Rogers, Technical Specialist, Civilian Radioactive Waste Management System Management and Operating Contractor (CRWMS M&O), Woodward Clyde Federal Services	Selected UZ Studies
Bill Nelson, Technical Specialist, CRWMS M&O, INTERA	Selected UZ Studies
William Belke, Observer, U.S. Nuclear Regulatory Commission (NRC)	
Steve McDuffie, Observer, NRC	
Robert Brient, Observer, NRC (Southwest Research Institute)	

4.0 AUDIT MEETINGS AND PERSONNEL CONTACTED

A field preaudit meeting was held in the Field Operations Center at the YMS on September 6, 1995, with USGS geologists, QA implementation staff, and NRC observers. A preaudit meeting was also held at the USGS offices in Denver, Colorado, on September 11, 1995. A daily debriefing and coordination meeting was held with USGS Yucca Mountain Project (YMP) management and staff to discuss issues and potential deficiencies. A daily audit team meeting was also held each evening to coordinate the

pace of the audit and to discuss issues, process recommendations, and potential deficiencies. The audit was concluded with a postaudit meeting held at the USGS offices in Denver, Colorado, on September 14, 1995. Personnel contacted during the audit are listed in Attachment 1. The list includes those who attended the preaudit and postaudit meetings.

5.0 SUMMARY OF AUDIT RESULTS

5.1 Program Effectiveness

The audit team determined that, in general, with the exception of areas identified as deficiencies, process controls are being effectively implemented by the USGS for UZ Field Studies; however, the audit team concluded that the UZ modeling effort had not properly implemented adequate programmatic controls to ensure an adequate product. The audit assessed four studies in different stages of completion.

5.2 Stop Work or Immediate Corrective Actions Taken

There were no Stop Work Orders or immediate corrective actions resulting from this audit.

5.3 QA Program Audit Activities

The audit consisted of the following selected work processes and products from beginning to end and determining that adequate QA controls were in place. Portions of QARD program elements 2, 4, 5, 7, 12, 16, 17, 18, and Supplement III were examined as applicable to the process/product examined.

Training and qualification records for individuals involved in producing the reports evaluated below were reviewed. The system that USGS uses to track training needs and completion was found to be very good, and the selected USGS people all had their training documented. It was found that training to USGS procedures for the Lawrence Berkeley Laboratory (LBL) personnel was lacking in several instances. See Section 5.5.1, deficiency document YMQAD-95-D016. Errors in LBL's qualification documentation were also identified. See Section 5.5.1, deficiency document YMQAD-95-C051.

The USGS calibration facility at the Hydrologic Research Facility (HRF) was examined and found to effectively implement controls for the instruments being calibrated and used in the UZ Field Studies. One minor deficiency was identified relative to calibration documentation. See Section 5.5.1, deficiency document YMQAD-95-P015.

Records packages for the four reports identified in Section 2.0 of this report were examined during the audit relative to technical review and records requirements identified in the critical process step and Sections 2 and 17 of the QARD. The reports reviewed by USGS were found in general to be properly executed and documented, an improvement over the report reviews examined during audit YMP-ARP-95-12. See Section 5.5.3 for follow-up on CARs YMP-95-045 and YMP-95-046. The LBL/USGS report, however, was found to have been improperly reviewed and approved. Personnel performing the reviews were not adequately trained. See Section 5.5.1, deficiency documents YMQAD-95-C051 and YMQAD-95-D016.

Examination of the selected field UZ reports discussed in Section 5.4 relative to identified critical process steps disclosed that data was collected, reviewed, and submitted adequately.

A summary table of audit results is provided in Attachment 2. The details of the audit evaluation, along with the objective evidence reviewed, are contained within the audit checklists. The checklists are kept and maintained as QA Records.

5.4 Technical Audit Activities

The performance based QA audit of the USGS UZ Field Studies focused on four products and associated processes. The products consisted of the four reports identified in Section 2.0 provided by USGS to the audit team. The processes consisted of the critical process steps identified by USGS as being necessary for the successful development of the report products. The reports provided were current in that they were still in various stages of development, review, and completion allowing the audit team to provide the USGS with real time input on their processes and products.

Technical checklist questions were developed from each report and the report authors/Principal Investigators (PI) were responsive in answering questions either in the field at Yucca Mountain or at the USGS offices in Denver, Colorado. The following comments on each of the four reports resulting from the UZ Field Studies provide the basis for the evaluation.

1) **Stratigraphic Relations and Hydrologic Properties of the Paintbrush Tuff Nonwelded (PTn) Hydrologic Unit, Yucca Mountain, Nevada**

(Study Plan 8.3.1.4.2.1, "Characterization of the Vertical and Lateral Distribution of Stratigraphic Units within the Site Area")

The technical specialist reviewed stratigraphic sections in the field and core samples at the Sample Management Facility that were described in this

report. In addition, the Study Plan and documentation for the reported studies were reviewed. The work reported on represents a concentrated effort to improve the understanding of a portion of Yucca Mountain stratigraphy that is very important for the development of the unsaturated zone flow model being developed by LBL. The work involves detailed subdivision of the PTn unit. This subdivision represents an important advance in understanding the stratigraphy of the unit. The data will be used to refine the representation of the PTn in hydrologic flow and transport models. This refinement is important because initial calculations indicate that the PTn has an important influence on flow through the unsaturated zone at Yucca Mountain.

The stratigraphic and lithologic divisions identified in this report provide a framework for the interpretation and modeling of data on the hydrologic properties of the PTn. Of particular importance are the contacts between the PTn and welded units above and below. These contact zones are characterized in this report in sufficient detail to facilitate hydrologic modeling of the unit. The report also contains initial data on hydrologic properties that will help direct future studies to provide more complete characterization of the units. One limitation of the report was that although almost all of the work had been qualified in accordance with the Participant Planning Sheet requirements, the report itself was classified as unqualified. See Section 5.5.1, deficiency document YMQAD-95-D017. There is also a concern regarding the timeliness of capture of some of the documentation into the QA records system. See Section 6.0, Item 3.

Conclusions

The work that has been done to support this study and report was conducted in a highly competent manner by well qualified geologists and geohydrologists. It will fulfill the needs of the U.S. Department of Energy's (DOE) site characterization program. The data required by modeling activities is being developed by these field and laboratory studies and the integration between modelers and data collectors is developing very well.

- 2) Fracture Character of the Paintbrush Tuff Nonwelded Hydrologic Unit, Yucca Mountain, Nevada

(Study Plan 8.3.1.4.2.2, "Characterization of Structural Features in the Site Area")

The technical specialist reviewed several pavements and outcrop exposures in the field that are discussed in this report. In addition, the Study Plan and documentation for the reported studies were reviewed.

This report summarizes a large data collection and analysis effort. The analysis includes the identification of fracture origin (cooling versus tectonic), fracture sets, and relative timing. The analysis has revealed a relatively complex chronology of fracture development. The analysis has also allowed an evaluation of the intensity and connectivity of the various fracture sets. This data will be important input for tectonic analyses and hydrologic modeling. The report provides important data on the connectivity of fractures through the PTn relative to fracture systems in the welded units above and below the PTn. Important correlations between fracture intensity and the physical and lithologic characteristics of the rocks are presented. It was found that one data package supporting the report had not been identified on the report's Technical Data Information Form (TDIF). The appropriate Data Tracking Number (DTN) was added during the audit. See Section 5.5.2, Item 1.

The audit found several problems with the report that summarizes this work. The problems identified were resolved through discussions with the PI before the completion of the audit. The PI agreed to make changes to the report, which was still in draft form at the time of the audit. See also Section 5.5.2, Item 2. The principal conclusions of the study were not affected by the errors and are a valuable contribution to project understanding of fracture development and history.

Important fracture data was collected for the project before the initiation of the study evaluated in this report. This earlier data was collected before the project's quality assurance program was approved. This earlier data has been compiled and was reviewed during the audit. Initial review suggests that the data was collected under procedures that were equivalent to those that are approved by the project today; i.e., GP-12, Revision 1, "Mapping Fractures on Pavements, Outcrops and Along Traverses," and HP-246, Revision 0, "Mapping fractures on Outcrops for Hydrologic Studies." The technical specialist recommends that this data be considered for qualification under the procedural equivalence method being developed by the CRWMS M&O. This data would be particularly useful to the project because it would greatly expand the quantity and areal coverage of the fracture data set. Hydrologic modeling efforts will require data from the areas included in this earlier data set. See Section 6.0, Item 2.

One deficiency was also noted in the scope of the report review process. See Section 5.5.1, deficiency document YMQAD-95-D018. Another problem in the way some review comments were incorporated in the report was corrected during the audit. See Section 5.5.2, Item 3.

Conclusions

The work that has been done to support this study and report was conducted in a competent manner by well qualified geologists. It will fulfill the needs of the DOE's Site Characterization Program. The data required by modeling activities are being developed by these field studies and the integration between modelers and data collectors is developing very well.

- 3) In Situ Borehole Instrumentation and Monitoring Data (October 25, 1994 through April 12, 1995) for USW NRG-7a and USW NRG-6, Yucca Mountain, Nye County, Nevada

(Study Plan 8.3.1.2.2.3, "Characterization of the Percolation in the Unsaturated Zone - Surface Based Study")

During field visits to the operating borehole monitoring sites (instrumented boreholes USW NRG-6, USW NRG-7a, UE-25 UZ #4, and UE-25 UZ #5), overall information was provided covering borehole instrument package installation and underground routing of electrical cables and tubing from the well head to the Insulated Instrument Shelters (IIS). The work is repetitive and is being conducted in accordance with technical procedure NWM-USGS-HP-137, Revision 1. The Principal Investigator is experienced in borehole instrumentation. The IIS contains: 1) the electronic data acquisition system, 2) the uninterruptible power supply and batteries, 3) the heating, ventilating, and air conditioning system used to maintain a controlled temperature environment inside the shelters, and 4) the automated telemetry equipment for data transfer to the HRF for subsequent daily transmittal of the assembled data to Denver.

The placement depths established for each Downhole Instrument Station Apparatus (DISA) package in USW NRG-6 and USW NRG-7a were checked in detail using the coring logs presented in Appendixes A and B of the USGS emplacement report. Specifically, both the planned and "as constructed" documentation in the report were inspected, compared, and verified using material Package Accession Number Mol. 19950414.0277 on file in the USGS Records Center in Denver. The subject report very carefully and completely recorded each installed downhole measuring device, its calibration and completed documentation for every device. The particulars of calibration procedures and associated records were reviewed in detail at the HRF and in Denver. This audit emphasized evaluation of the data obtained, the quality handling of such data, detailed reporting of that data, and the

subsequent use of such quality data in site characterization for process model synthesis and testing. One weakness was noted in this audit regarding documentation of the organization performing the calibrations. See Section 5.5.1, deficiency document YMQAD-95-P015.

Each DISA package installed at a given depth contains two pressure transducers, two thermistors, and two thermocouple psychrometers. Operational redundancy is employed, primarily for measurement verification, and secondarily for providing a backup measurement capability in the event of failure of either one of the sensors. The DISA also contains two solenoid valves and is connected to a pair of tubes that run from the ground surface to the downhole instrument station and back to the ground surface. These tubes are used for: 1) sampling formation rock gases, 2) verifying downhole measurements of water potential made from the thermocouple psychrometer, 3) introducing tracer gases for gas tracer diffusion tests, 4) in situ recalibration of the downhole pressure transducers, and 5) uphole measurement of pneumatic pressure inside the instrument station in the event of a failure. These capabilities are made possible by energizing one or both of the solenoid valves housed inside the DISA. Such a very carefully planned and integrated scheme of operational redundancy, cross-checking of the related measurements, and highly interrelated data acquisition together yield both expected values and variance output, which represents significant excellence in hydrologic site characterization.

The assembled basic telemetry data transmitted daily to USGS in Denver is archived in both the Denver USGS Records Center and in the project data base, and so is generally available throughout the project. The individual data reports (as reviewed here) summarize the results and also contain data files on diskettes for the periods reported. The data is available then on diskettes, in the reports for users, in project data bases, and very soon will also be available on one gigabyte CD-ROM storage devices.

Particularly adverse weather conditions occurred during installation of instruments into USW NRG-6. Nighttime temperatures well below freezing, meant cold hardware (tubing, electrical cables, DISAs, etc.) was introduced into a warmer, moist borehole causing condensation to form inside the DISA and other electrical connections. Outstanding efforts during and following installation by the staff enabled correction of the problems by flowing dry nitrogen through the downhole system. Auditors support the technical staff in their position of scheduling installation to prevent such problems recurring. Accordingly, an Audit Recommendation covering winter installation of instrumentation into boreholes was made. See Section 6.0, Item 1.

Among the important and first direct application of this data is in testing and improving the calibration of the three-dimensional site scale unsaturated zone models. Selected data from the measured air phase pressure histories from

these studies that occur as storm fronts pass over Yucca Mountain are provided to the site scale modelers. The site modelers use the partial air pressure data sets in the synthesized site unsaturated model and calculate the model air phase pressure histories for the several measurement depths at the instrumented borehole locations and return the calculated pressure distribution histories for comparison with the remaining original withheld data. Such comparisons provide among the best possible overall large scale tests of the three-dimensional unsaturated zone flow models.

Conclusions

The extensive work that has and continues to be done in this study and the report was conducted in a highly competent manner by well qualified hydrologists, scientists, instrumentation specialists, and data acquisition staff members cooperatively functioning together as an effective team in surface-based testing. Such surface-based testing progress is vital to fulfilling the DOE's site characterization program, which is the major contributor in the synthesis of field data into process level models that adequately represent the site.

4) Preliminary Development of the LBL/USGS Three-Dimensional Site-Scale Model of Yucca Mountain, Nevada

(Study Plan 8.3.1.2.2.9, "Site Unsaturated-Zone Modeling and Synthesis")

This report summarizes the initial work done to develop the three-dimensional site-scale unsaturated zone flow model for Yucca Mountain. At this initial stage only very general information about the stratigraphy and structural geology of the site can be included in the model. For instance, everyone interviewed for this portion of the audit agreed that fracture data will be important for the proper development of this model, but at this early stage no fracture data has been incorporated into the model. The conceptual model presented in the study plan is being developed and refined as data collection and modeling efforts move forward. Refinement of the conceptual model is an important activity, to ensure that the maximum benefit is derived from both data collection and modeling activities, and needs to be documented in scientific notebooks developed during the course of the study.

The study plan for site unsaturated-zone modeling and synthesis discusses five major objectives or activities:

1. Conceptualization of unsaturated-zone hydrogeologic system
2. Selection, development, and testing of hydrologic flow computer codes
3. Site unsaturated-zone integration and synthesis
4. Simulation of the natural hydrogeologic flow system

5. Stochastic modeling and uncertainty analysis

These together enable the effective synthesis into a useful process model of the site characterization data thereby providing the basis for understanding and assessing the longer term performance of the Yucca Mountain Site. Major study plan activities 3 and 4 are those areas primarily involved in the LBL-37356 report. Progress in these two study plan areas is presented for the first iteration unsaturated flow process model; i.e., for the preliminary three-dimensional UZ flow model of the site. Also discussed during the audit interview with LBL staff was their initial thoughts on their next study, "Intermediate Three-dimensional Site-Scale Unsaturated Flow Model," for development possibly during fiscal year (FY) 1996.

The preliminary unsaturated zone site flow model is generally bounded laterally on the west by the Solitario Canyon Fault, on the east by the Bow Ridge Fault, to the north by the inferred Yucca Wash Fault, and to the south the boundary is beyond the branching of the Ghost Dance Fault into the abandoned Wash Fault and Dune Wash Fault. In the third dimension or vertically, the bottom of the preliminary site model was the water table and it extended upward to include the various stratified rock materials effectively to the ground surface. With the major fault representations the documented preliminary model has just under 5,000 nodes; and with the additional gridding to include the Exploratory Studies Facility (ESF), then between 10,000 and 11,000 nodes are involved in the preliminary 3D model. Representative running times for solutions, depending on problem complexity and size (with or without the ESF), range from 4 to 20 hours on an IBM Reduced Instruction Set Computer (RISC) work station.

The various UZ model calibrations and perched water evaluation activities done in FY 1995 that are being reported as informal FY 1995 deliverables were all conducted using the preliminary UZ model. Specifically involved were: 1) moisture tension calibrations with UZ well data, 2) temperature calibration with earlier field thermal data, and 3) gas phase pressure calibrations and testing (See Study Plan 8.3.1.2.2.3, Paragraph 7).

The interviews also included discussion of the proposed Intermediate Three-dimensional Site-Scale Unsaturated Flow Model that may be developed during FY 1996. This tentative model development is planned to cover a four times larger area than the present preliminary UZ model. The expanded lateral model size extends the new boundaries well beyond those of the present preliminary first iteration boundaries and represents an important model improvement. The extended west boundary will then be well beyond the Solitario Canyon Fault and the new east boundary is beyond Forty Mile Wash. Both the northern and southern boundaries are also extended in the proposed larger model. Also, greater stratigraphic detail is planned. For example, better hydrologic description of the PTn involves increasing the present three to five layers of varying thickness in the proposed intermediate

UZ model. These improvements were indicated as requiring expansion in node numbers to 20,000 to 30,000 or more with expected model running times of the order of 50 hours on an IBM RISC work station. By way of comparison, the present operational Finite Element Heat and Math three-dimensional unsaturated flow model portion of the Los Alamos National Laboratory (Los Alamos) Site-Scale Integrated Transport Model has between 50,000 to 52,000 nodes with typical running times of 1 to 2 hours on an IBM RISC work station.

During the audit interviews on the preliminary three-dimensional site-scale unsaturated flow model, significant emphasis was on evaluating the effectiveness of communication between site characterization PIs and those developing the unsaturated process models. Specifically, the audit objective was to determine how well the understanding of the site and data is transferred into model synthesis, calibration, and improvement of the site representation. Only part of the nine overall site characterization study plans that feed the Site Unsaturated-Zone Modeling and Synthesis Work Plan could be considered in this audit. Specifics considered included:

1. Characterization of Yucca Mountain Stratigraphic Units to provide major geologic and hydrologic stratigraphy in the model
2. Stratigraphic relationship and hydrologic properties of the Paintbrush Tuff
3. Fracture characteristics of the Paintbrush Tuff Nonwelded Hydrologic Unit
4. Measured data in boreholes in time (temperature, capillary pressure, air phase pressure, and gas phase samples)

The communication and coordination of these field characterization, data collection, and laboratory studies with the modelers has and is functioning very well. This was obvious in the modelers' knowledge of current issues discussed at the site. A key to this coordination has been regular meetings between the LBL and USGS modelers and USGS scientists involved in the data collection. It is clear that the modelers and the data collectors are developing strong lines of communication that will help ensure adequate coordination for the project on work done in the UZ program. Similar lines of communication need to be strengthened between the LBL modelers and the Los Alamos modelers who will use the LBL output.

The audit found several problems with the report development sequence for published report LBL-37356. The original draft of the document (designated here as dated June 1994) was found to have undergone inadequate technical review by LBL technical staff as determined through examination of the "YMP-USGS Data, Publication Review/Comment Resolution Forms." This draft was submitted to DOE in September 1994 for programmatic review. A program review was performed and the document was given DOE approval. The CRWMS M&O

Performance Assessment (PA) technical staff provided an additional detailed review of the approved draft as requested by the DOE PA staff. That review resulted in 42 technical comments plus additional editorial comments formally submitted on YMP Document Review Sheets. Ultimately those review comments were transmitted from the DOE staff to the USGS, who discussed with LBL the detailed review comments and assigned LBL the responsibility for detailed comment resolution with the CRWMS M&O performance assessment reviewers. The resolution of the 42 YMP review sheet comments was not completed at that time.

After LBL became a project participant under the new direction of the CRWMS M&O; i.e., in late July 1995, a substantially revised draft of the Preliminary Model report (dated June 1995) was given by LBL to CRWMS M&O. This report incorporated only part of the 42 comments discussed above. About a month later, final published copies of this version began to become available, although formal distribution had not yet occurred. However, the USGS technical staff, some of whom are listed as authors, apparently saw and also received copies of the printed document LBL-37356 for the first time during the USGS audit. Because of these and other oversight problems, CAR YMQAD-95-C051 was issued. See Section 5.5.1.

There is one additional concern regarding the LBL UZ modeling support to USGS. During the USGS audit YM-ARP-95-04, conducted during December 1994, CAR YMP-95-22 was initiated to document that no formal QA requirements controlled the ongoing work. As part of that effort, LBL was developing the TOUGH2 code. USGS indicated that they attempted to get LBL to initiate QA controls in the form of a scientific notebook and apply software QA controls to the TOUGH2 work. There is no objective evidence that LBL initiated any formal controls from December 1994 until LBL assumed responsibility for implementation of their own QA program in July 1995. LBL is presently "calibrating" and refining the TOUGH2 code based on current borehole data sets. This is an area of concern that will be followed up during the LBL audit in Fiscal Year 1996, which is scheduled for October 1995.

Conclusions

The work done by the USGS and LBL technical staffs to provide site characterization data and cooperatively facilitate model development has been done in a competent manner by well qualified professional geologists, hydrologists, and scientific modelers. It will fulfill the needs of the DOE's site characterization program. The modeling activities are being coordinated with the field and laboratory studies and the integration between modelers and data collectors is developing very well. It is unfortunate that the efforts of such capable professional contributors are overshadowed by the lack of LBL administrative control and resulting passive response in providing timely quality deliverables.

A summary table of audit results is provided in Attachment 2. The details of the audit evaluation, along with the objective evidence reviewed, are contained within the audit checklists. The checklists are kept and maintained as QA Records.

5.5 Summary of Deficiencies

The audit team identified five deficiencies during the audit for which one CAR, three DRs, and one PR have been issued. Three additional deficiencies were identified and corrected prior to the postaudit meeting.

Synopses of deficiencies documented are detailed below. The corrective action documents generated during this audit have been transmitted to USGS under separate letters, numbers YMQAD:RBC-4666, dated September 26, 1995, and YMQAD:MRD-4518, dated September 14, 1995.

5.5.1 Corrective Action Documents Initiated

As a result of the audit, the following CAR was issued:

YMQAD-95-C051

This CAR documents that the USGS failed to implement adequate control over contractor activities to ensure proper implementation of the QA program. Deficiencies were seen in documentation of activities, report review, training, and personnel qualification.

The following DRs were issued:

YMQAD-95-D016

It was found that training to USGS procedures for LBL personnel was lacking in several instances.

YMQAD-95-D017

A report was found that was classified as "not qualified" but had been prepared under a "Q" Work Breakdown Structure and Participant Planning Sheets. The report had been submitted and approved by the DOE, but the USGS had not notified the DOE that the report was not qualified. DOE had not approved the production of an unqualified report.

YMQAD-95-D018

It was found that the technical review of reports did not include a reference to the data sources to assure that the report correctly compiled the data. The referenced section of the QARD was implemented in procedures governing

software, procurement documents, procedures, and scientific notebooks, but was not incorporated in Quality Management Procedure YMP-USGS-QMP-3.04, Revision 6, "Review and Approval of YMP USGS Data, Interpretations of Data, and Manuscripts." The implementation of the requirement must clearly direct the performance of an adequate review as specified in QARD, Section 2.2.9.

In the case of procedure YMP-USGS-QMP-3.04, although the procedure does provide for a review, it fails to require the reviewers to assure the correctness of the document they are reviewing. YMP-USGS-QMP-3.04, Paragraph 5.2 states, "The author, through the YMP-USGS Reports Specialist, shall provide the reviewers with copies of the manuscript accompanied by appropriate documents, as well as a copy of the data review documentation" Therefore, the reviewer need only assure that a data review was done, not that the data was correctly transferred to the technical report they are reviewing. As an example, the technical reviewers for report "Fracture Character of the Paintbrush Tuff Nonwelded Hydrologic Unit, Yucca Mountain, Nevada" did not refer to the supporting data packages when performing their reviews. The scope of review was documented by one reviewer as only being of the report itself. The other technical reviewer stated that the review was only of the report and did not include looking at the data in the data packages. The problem is that there is no review to assure that data from the data package was properly transcribed into the report. Discussions with management confirmed that the normal expectation does not require the technical reviewers to do such a review. The USGS in practice considers this the sole responsibility of the author. An example of a clear incorporation of the requirement is given in the Office of Civilian Radioactive Waste Management Quality Assurance Procedure 6.2, Revision 2, "Document Review," Attachment 9.4, Paragraph 2.10, which states, "Does the final document correctly incorporate technical input?"

The following PR was issued:

YMQAD-95-P015

It was found that calibration records did not document the organization (vendor) that actually performed the calibrations.

5.5.2 Deficiencies Corrected During Audit

Deficiencies which are considered isolated in nature and only requiring remedial action can be corrected during the audit. The following deficiencies were corrected during the audit regarding the report, Fracture Character of the Paintbrush Tuff Nonwelded Hydrologic Unit, Yucca Mountain, Nevada :

1. Contrary to the requirements of Paragraph 5.1.1 of YAP-SIII.3Q, Revision 0, the TDIF for the report did not reference one DTN for a supporting data package. Several other DTNs had been correctly referenced. The TDIF for the report was revised to reference the missing DTN during the audit.
2. Four technical errors were found even though the report had been through the review process. None of these errors affected the major conclusions of the report. The PI agreed to make the changes to the report, which was still in draft form at the time of the audit.
3. Contrary to the requirements of Paragraph 5.1.3 of YMP-USGS-QMP-3.04, Revision 6, some review comments had been incorporated by the reviewer rather than by the originator. Therefore, no review was performed for those corrections. A review of those changes was documented before the end of the audit.

5.5.3 Follow-up of Previously Identified Deficiencies

Five deficiencies (CARs YM-95-21, YM-95-042, YM-95-045, YM-95-046 and YM-95-048) from previous audits required follow-up during the course of this audit.

CAR YM-95-021 identified a deficiency relative to the calibration intervals for standards used in the HRF to perform calibrations of instrumentation. During the audit, implementation of the corrective action commitments for this CAR was verified as satisfactory and complete. The CAR was subsequently closed.

CAR 95-042 identified a deficiency relative to the lack of criteria in establishing trends and the lack of documentation in the closure of USGS initiated corrective actions. USGS is no longer responsible for trending, and the needed documentation has been provided. An impact analysis was performed for this CAR. Based on the verification actions, this CAR was subsequently closed.

CARs YM-95-045 and YM-95-046 dealt with the adequacy of technical reviews and technical adequacy of USGS reports. While overall corrective action is still ongoing, the evaluation of a technical report, In Situ Borehole Instrumentation and Monitoring Data (October 25, 1994 through April 12, 1995) for USW NRG-7a and USW NRG-6, Yucca Mountain, Nye County, Nevada, reviewed and approved by USGS subsequent to identifying this problem was found technically adequate and properly reviewed. However, some weaknesses were noted in the report, Fracture Character of the Paintbrush Tuff Nonwelded Hydrologic

Unit, Yucca Mountain, Nevada. The audit team did note an improvement in the identification and documentation of resolution of comments in accordance with USGS-QMP-3.04. The overall corrective actions to preclude recurrence have not been established yet and additional follow-up will be required.

CAR YM-95-048 identified the lack of flowdown from procedure USGS-YMP-QMP 8.01, Revision 4, "Control of Samples," into the technical implementing documents. USGS modified and deleted several procedures and added entries to scientific notebooks which involved the control of samples. Based on the objective evidence examined, and satisfactory completion of the required corrective action, this CAR was subsequently closed.

6.0 RECOMMENDATIONS

The following recommendations resulted from the audit and are presented for consideration by USGS management:

1. The project has already correctly identified, but the audit team wished to reinforce, that borehole instrumentation cannot be installed during adverse winter conditions. The USGS is expected to install instrumentation in boreholes USW NRG-7a and USW SD-12 in the near future. It is recommended that the PI have final approval on the day of the placement of these instrument packages.
2. There is a data package that has been compiled from geologic data collected over a period of years by Barton, Throckmorton, and Verbeek. This data is classified as unqualified. This data represents a more complete coverage of the site than is possible by using qualified data alone. The nature of this data is such that it is likely that the data could be reviewed and qualified. The technical specialist recommends that this data be considered for qualification under the procedural equivalence method being developed by the CRWMS M&O. This data would be particularly useful to the project because it would greatly expand the quantity and areal coverage of the fracture data set. Hydrologic modeling efforts will require data from the areas included in this earlier data set.
3. The QARD provides for collection of quality assurance records, but does not require collection and protection of records that are not complete. In the case of scientific notebooks, it is the practice to submit these to records once they are completed. Scientific Notebook USGS-SN-0001D has incorporated field notepads into it by reference. There exists two file drawers of such notepads, none of which have been submitted to the Records Processing Center. The individual notepads are completed and signed off. Some notepads had pages which had not been numbered or signed on each page. This scientific notebook spans a lengthy period of time. It is not stored in a fireproof cabinet. In such cases it is recommended that provisions be made for a more timely review of adequacy and capture of this information in the QA records system.

7.0 LIST OF ATTACHMENTS

Attachment 1: Personnel Contacted During the Audit

Attachment 2: Summary Table of Audit Results

ATTACHMENT 1

Personnel Contacted During the Audit

Name	Organization/Title	Preaudit		Contacted During Audit	Postaudit Meeting
		Meeting	Field Denver		
Anna, L.O.	USGS/Hydrologist			X	X
Bandurraga, M.	LBL/Sr. Research Associate			X	
Bowen, R.P.	USGS/QAIS	X	X		
Branch, A.	USGS/QAIS		X		
Burgess-Kohn, K.	USGS/SAIC/Training Coordinator			X	X
Cacaro, V.R.	USGS/SAIC/QAIS	X	X	X	X
Cates, J.	USGS/FEC/Hydro Technician			X	
Chaney, T.H.	USGS/QA Manager		X	X	X
Craig, R.W.	USGS/Acting TPO		X		
Day, W	USGS/Chief, Structural Studies	X	X	X	X
Flint, L.	USGS/Hydrologist	X			
Frey, B.	USGS/QAIS	X	X	X	X
Geslin, J.K.	USGS/ Geologist	X	X	X	X
Getzen, R.T.	USGS/Hydrologist	X		X	
Gillies, D.C.	USGS/Chief UZ Studies		X	X	X
Gockel, D.J.	USGS/QA		X	X	X
Greengard, A.J.	USGS/Tech Systems Specialist ESIP		X	X	X
Kwicklis, E.M.	USGS/Hydrologist			X	X
Lu, N.	USGS/Hydrologist				X
Luckey, R.R.	USGS/SZ & EM Team Chief				X
Lykins, A.E.	USGS/QA Specialist		X		
Miller-Corbett, C.	USGS/QAIS	X	X	X	X
Mustard, M.H.	USGS/QA		X	X	X
Moyer, T.C.	USGS/Geologist	X	X	X	
Myers, D.R.	USGS/Hydrologist	X		X	
Parks, B.	USGS/Asst. Chief ESIP		X		
Porter, D.D	USGS/SAIC Contract Manager		X		
Rodman, W.	USGS/QA (M&TE)				X
Rosseau, J.P.	USGS/Project Chief Hydrologist		X	X	X
Royer, D.C.	USGS/FEC/Hydro Technician			X	
Stuckless, J.S.	USGS/Senior Science Advisor	X		X	

ATTACHMENT 1

Personnel Contacted During the Audit

Name	Organization/Title	Preaudit		Contacted During Audit	Postaudit Meeting
		Meeting	Field Denver		
Sweetkind, D.	USGS/Geologist	X	X	X	X
Watt, L.	USGS/Records Coordinator			X	
Whiteside, A.	USGS/SAIC/QAIS		X		X
Williams, R.S.	USGS/Chief ESIP		X		X
Williams-Stroud, S.	USGS/Geologist			X	
Woolverton, J.	USGS/QA Specialist	X	X	X	X
Wu, Y.	LBL/Staff Scientist			X	

LEGEND:

- EM . . . Environmental Monitoring
- ESIP .. Earth Science Investigations Program
- FEC .. Foothills Engineering Corporation
- M&TE Metrology and Test Equipment
- PI Principal Investigator
- QAIS . Quality Assurance Implementation Specialist
- SAIC . Science Application International Corporation
- SZ Saturated Zone
- TPO .. Technical Project Officer

ATTACHMENT 2
SUMMARY TABLE OF AUDIT RESULTS

AUDIT YM-95-20 DETAIL SUMMARY

QA ELEMENT/ ACTIVITIES	PROCESS STEPS	CHECKLIST DETAILS	CAR, DR or PR	CDA	RECOM- MENDA- TIONS	ADE- QUACY	COMP- LIANCE	OVER- ALL
General - Site Unsaturated Zone Studies	Personnel are qualified, have relevant background experience and are trained	Item A-1,D-1, D-2 pp. 2, 2A, 38 of 57	YMQAD- 95 -C051 & -D016	N	N	UNSAT	N/A	UNSAT
	Adequate management resources have been provided; e.g. lines of communication, personnel, equipment, feedback, realistic milestones	Items A-2&6, C.1-1, D-4 thru -8 pp. 2,2B,4, 22, 39- 41A of 57	YMQAD- 95-C051	N	N	UNSAT	N/A	
	Use of a documented, controlled system; procedures, scientific notebooks	Items A-3, D-9 thru -12 pp. 3,3A,42-43 of 57	YMQAD- 95-C051	N	Sec. 6.3	UNSAT	N/A	
	Qualification of data and intended use.	Items A-4&5, D-13, D-14 pp.3,4,4A,43 of 57	YMQAD- 95 -D017	N	N	UNSAT	N/A	
	Special equipment- M&TE use (See previous audit YM- ARP-95-12)	Items A-7, A-8 pp. 5,5A of 57	YMQAD- 95 -P015	N	N	UNSAT	N/A	
	Data analysis/reviews/ Database	Items A-9 thru A-12, C.1-2 pp. 6-7A, 23 of 57	YMQAD- 95 -C051, -D016, &- D018	Sec. 5.5.2 1 thru 3	N	UNSAT	N/A	

ATTACHMENT 2
SUMMARY TABLE OF AUDIT RESULTS

QA ELEMENT/ ACTIVITIES	PROCESS STEPS	CHECKLIST DETAILS	CAR, DR or PR	CDA	RECOM- MENDA- TIONS	ADE- QUACY	COMP- LIANCE	OVER- ALL
1. Stratigraphic Relations and Hydrologic Properties of the Paintbrush Tuff Nonwelded (PTn) Hydrologic Unit, Yucca Mountain, Nevada	Identify product based on needs identified in SCP	Items B.1-1 p. 8 of 57	N	N	N	SAT	N/A	SAT
	Identify data needs required to produce product	Items B.2-1,B.2-2 pp. 8, 9 of 57	N	N	N	SAT	N/A	
	Collect data	Items B.3-1 thru-3 pp. 9, 10 of 57	N	N	N	SAT	N/A	
	Analyze/interpret data	Items B.4-1 thru -5 pp. 11-13 of 57	N	N	N	SAT	N/A	
	Develop report/(product)	Item A-5 p. 4A of 57	YMQAD-95-D017	N	N	UNSAT	N/A	
	Review report (technical,QA,peer)	Item A-10 pp. 6A, 6B of 57	N	N	N	SAT	N/A	
	Respond to review comment and/or incorporate comments	Item A-10 p. 6A of 57	N	N	N	SAT	N/A	
	Submit final report (products) to DOE	Items A-5,A-11, A-12 pp. 4A, 7, 7A of 57	YMQAD-95-D017	Sec. 5.5.2.1	N	UNSAT	N/A	

**ATTACHMENT 2
SUMMARY TABLE OF AUDIT RESULTS**

QA ELEMENT/ ACTIVITIES	PROCESS STEPS	CHECKLIST DETAILS	CAR, DR or PR	CDA	RECOM- MENDA- TIONS	ADE- QUACY	COMP- LIANCE	OVER- ALL
2. Fracture Character of the Paintbrush Tuff Nonwelded Hydrologic Unit, Yucca Mountain, Nevada	Identify product based on needs identified in SCP	Items B.1-1 p. 14 of 57	N	N	N	SAT	N/A	SAT
	Identify data needs required to produce product	Items B.2-1 thru -5 pp. 14-16 of 57	N	Sec. 5.5.2.2	N	SAT	N/A	
	Collect data	Items B.3-1 thru -10 pp. 17-21A of 57	N	Sec. 5.5.2.2	Sec. 6.2	SAT	N/A	
	Analyze/interpret data	Item A-10 p. 6A of 57	N	N	N	SAT	N/A	
	Develop report/ (product)	Item A-10 p. 6A of 57	N	N	N	SAT	N/A	
	Review report (technical,QA,peer)	Item A-10 pp. 6A, 6B, 6C of 57	YMQAD- 95-D018	Sec. 5.5.2.2	N	UNSAT	N/A	
	Respond to review comment and/or incorporate comments	Item A-10 p. 6A of 57	N	Sec. 5.5.2.3	N	SAT	N/A	
	Submit final report (products) to DOE	A-11, p. 7	N	N	N	UNSAT	N/A	

ATTACHMENT 2
 SUMMARY TABLE OF AUDIT RESULTS

QA ELEMENT/ACTIVITIES	PROCESS STEPS	CHECKLIST DETAILS	CAR, DR or PR	CDA	RECOMMENDATIONS	ADEQUACY	COMPLIANCE	OVERALL
3. InSitu Borehole Instrumentation and Monitoring Data (October 25, 1994 through April 12, 1995) for USW NRG-7a and USW NRG-6, Yucca Mountain, Nye County, Nevada	Identify product based on needs identified in SCP	Items C.3-1 pp. 30 of 57	N	N	N	SAT	N/A	SAT
	Identify data needs required to produce product	Items C.3-2 thru -6 pp. 30-32A of 57	N	N	N	SAT	N/A	
	Collect data	Items C.3-7 thru -10 pp. 33-34 of 57	N	N	Sec. 6.1	SAT	N/A	
	Analyze/interpret data	Items A-9,C.3-11 thru -15 pp. 6,35-37 of 57	N	N	N	SAT	N/A	
	Develop report /(product)	Item A-10 p. 6 of 57	N	N	N	SAT	N/A	
	Review report (technical,QA,peer)	Item A-11 p. 7 of 57	N	N	N	SAT	N/A	
	Respond to review comment and/or incorporate comments	Item A-11 p. 7 of 57	N	N	N	SAT	N/A	
	Submit final report (products) to DOE	A-11, p. 7	N/A	N/A	N/A	N/A	N/A	

**ATTACHMENT 2
 SUMMARY TABLE OF AUDIT RESULTS**

QA ELEMENT/ACTIVITIES	PROCESS STEPS	CHECKLIST DETAILS	CAR, DR or PR	CDA	RECOMMENDATIONS	ADEQUACY	COMPLIANCE	OVERALL
4. Preliminary Development of the LBL/USGS Three-Dimensional Site-Scale Model of Yucca Mountain, Nevada	Identify product based on needs identified in SCP	Items D-15, -17, -30 thru -32 pp. 44, 45, 52, 53 of 57	N	N	N	SAT	N/A	UNSAT
	Identify data needs required to produce product	Item D-16,-18,-19,-22, -26,-28,-33,-35 pp. 44-47, 49, 50, 53, 54 of 57	N	N	N	SAT	N/A	
	Collect data	Item D-34 p. 54 of 57	N	N	N	SAT	N/A	
	Analyze/interpret data	Items D-20, -21,-23, -24, -25, -27, -29, -36 thru -39 pp.46-51,55,56of 57	N	N	N	SAT	N/A	
	Develop report /(product)	Items A-10,D-5,D-6 pp. 6, 40, 40A of 57	YMQAD-95-C051	N	N	UNSAT	N/A	
	Review report (technical,QA,peer)	Items A-11,D-6,7,8 pp. 7, 40- 41A of 57	YMQAD-95-C051	N	N	UNSAT	N/A	
	Respond to review comment and/or incorporate comments	Item D-6 pp. 40, 40A of 57	YMQAD-95-C051	N	N	UNSAT	N/A	
	Submit final report (products) to DOE	Item D-6 pp. 40, 40A of 57	YMQAD-95-C051	N	N	UNSAT	N/A	
TOTAL		79	5	3	3			SAT*

LEGEND:

CDA ... Corrected During Audit
 N None

N/A Not Applicable
 SAT Satisfactory

SCP ... Site Characterization Plan
 UNSAT Unsatisfactory

*SAT for USGS, but UNSAT for USGS work by LBL