

U.S. NUCLEAR REGULATORY COMMISSION
OBSERVATION AUDIT REPORT OA-95-11
OF THE YUCCA MOUNTAIN QUALITY ASSURANCE DIVISION
AUDIT YM-ARP-95-20
OF THE U.S. GEOLOGICAL SURVEY

J. S. Schraul for 10/19/95
Robert D. Brient (per telephone)
Center for Nuclear Waste
Regulatory Analyses

J. S. Schraul for 10/19/95
William U. Belke (per telephone)
High-Level Waste Projects &
Quality Assurance Section
High-Level Waste & Uranium
Recovery Projects Branch
Division of Waste Management

Stephen M. McDuffie 10/19/95
Stephen M. McDuffie
Geosciences/Geotechnical
Engineering Section
Engineering and Geosciences Branch
Division of Waste Management

Reviewed and approved by:

John O. Thoma 10/30/95
John O. Thoma, Section Leader
High-Level Waste Projects &
Quality Assurance Section
High-Level Waste & Uranium
Recovery Projects Branch
Division of Waste Management

ENCLOSURE 1

9511150248 951102
PDR WASTE
WM-11 PDR

1.0 INTRODUCTION

Members of the U.S. Nuclear Regulatory Commission Division of Waste Management quality assurance (QA) and geosciences staff observed the U.S. Department of Energy (DOE), Office of Civilian Radioactive Waste Management (OCRWM), Office of Quality Assurance (OQA), Yucca Mountain Quality Assurance Division (YMQAD) audit of selected technical activities of the U.S. Geological Survey (USGS). The audit, YM-ARP-95-20, was conducted at Yucca Mountain (YM), Nevada on September 6-7, 1995, and at the USGS offices in Denver, Colorado from September 11-14, 1995.

The objective of the audit by YMQAD was to evaluate selected USGS scientific investigation activities and the quality of the resultant end products associated with the series of activities leading to the development of the unsaturated zone (UZ) hydrologic model of YM. These activities are identified in Section 4.1 of this report.

The NRC staff objective was to gain confidence that YMQAD and the USGS are properly implementing the requirements of their QA programs in accordance with the OCRWM Quality Assurance Requirements and Description (QARD: DOE/RW-0333P) and Title 10 of the Code of Federal Regulations (10 CFR), Part 60, Subpart G (which references 10 CFR Part 50, Appendix B).

This report addresses the effectiveness of the YMQAD audit and the adequacy of implementation of QA controls in the audited areas of the USGS QA program.

2.0 MANAGEMENT SUMMARY

This audit evaluated the implementation of the USGS QA program for activities associated with the flow of data from field geologic and hydrologic investigations through development of an UZ hydrologic model for YM. The State of Nevada was not represented at this audit.

The NRC staff determined that the audit was effective. The audit team found that the USGS QA program had been effectively implemented in the areas audited, with the exception of the activities associated with the UZ model development, which was indeterminate. The NRC staff agrees with these conclusions. One draft Corrective Action Request (CAR) was discussed at the exit meeting. It identified deficiencies in applying appropriate QA controls (including no software QA controls applied to the TOUGH2 code), inadequate personnel training, and inadequate technical reviews associated with the modeling efforts. In addition, three draft Deficiency Reports (DRs) and one draft Performance Report (PR) were initiated as a result of the audit.

3.0 AUDIT PARTICIPANTS

3.1 NRC

William Belke	QA Observer (Denver only)	
Stephen McDuffie	Technical Observer (YM only)	
Robert Brient	QA Observer (Denver only)	Center for Nuclear Waste Regulatory Analyses

3.2 DOE

Kenneth Gilkerson	Audit Team Leader (ATL)	YMQAD
Alan Rabe	ATL in Training	YMQAD
James Blaylock	Auditor	YMQAD
Ralph Rogers	Technical Specialist (Geology)	Civilian Radioactive Waste Management and Operating Contractor (M&O)
Bill Nelson	Technical Specialist (Hydrology)	M&O

4.0 REVIEW OF THE AUDIT AND AUDITED ORGANIZATION

This YMQAD audit of the USGS was conducted in accordance with OCRWM Quality Assurance Administrative Procedure (QAAP) 18.2, "Audit Program" and QAAP 16.1, "Corrective Action." The NRC staff observation of this audit was based on the NRC procedure, "Conduct of Observation Audits," issued October 6, 1989.

4.1 Scope of the Audit

The following technical areas concerned with developing the UZ model for YM were identified in the Audit Plan and were audited by the YMQAD audit team:

- Work Breakdown Structure (WBS) 1.2.3.2.2.1.1 - Vertical and Lateral Distribution of Stratigraphic Units Within the Site Area
- WBS 1.2.3.2.2.1.2 - Structural Features Within the Site Area
- WBS 1.2.3.3.1.2.3 - Percolation in the UZ - Surface Based Study
- WBS 1.2.3.3.1.2.9 - Site UZ Hydrologic Modeling

The following technical documents were audited by the YMQAD audit team:

- "Fracture Character of the Paintbrush Tuff Nonwelded Hydrologic Unit, Yucca Mountain, Nevada" - Undated Draft
- "Stratigraphic Relations and Hydrologic Properties of the Paintbrush Tuff Nonwelded Hydrologic Unit, Yucca Mountain, Nevada" - Draft transmitted to DOE by transmittal dated August 3, 1995
- "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" - Draft dated May 31, 1995
- "Preliminary Development of the LBL/USGS Three-Dimensional Site-Scale Model of Yucca Mountain, Nevada" - June 1995

The Key Technical Issue associated with the audit is "Hydrologic Characterization of Structural Features Which Significantly Affect Water and Vapor Movement."

4.2 Conduct Of Audit

The audit was performed in a professional manner and the audit team was well prepared. The audit plan identified this as a performance-based audit in which the evaluation of process effectiveness and product acceptability would be based upon 1) satisfactory completion of the critical process steps, 2) acceptable results and quality of the end product, 3) documentation that substantiates quality of products, 4) performance of trained and qualified personnel, and 5) implementation of applicable QA program elements.

In addition to being performance-based, this audit was also primarily a technical audit, the evaluations being lead by the hydrology technical specialist or the geology technical specialist along with a QA auditor. The five bases for the evaluations were generally addressed. However, technical examination of supporting documentation, particularly scientific notebooks and technical reviews, was limited. The NRC believes that performance-based technical audits should focus on all points in the process at which technical judgements are made. DOE OQA may need to reevaluate its approach to performance-based technical audits to ensure that all important technical and performance-related audit criteria are satisfied.

Caucuses were held daily between the audit team and the observers. Also, meetings of the ATL and USGS management (with an NRC observer present) were held daily to discuss the then-current audit status and preliminary findings.

The NRC has previously recognized a number of good audit practices through observation of OQA audits, such as tracking the status of potential findings and presenting findings based on requirements violated. However, these were not always followed during this audit. DOE should ensure through appropriate training that previously recognized good audit practices are followed.

4.3 Examination of Audited Areas

The audit followed the process of developing the UZ hydrologic model from geologic and hydrologic field investigations (audited at YM) through conceptual and mathematical model development (audited at Denver). The field portion of the audit focused on the methods of gathering the geologic data, which is later analyzed and input to the UZ hydrologic model framework. The audit team divided into two, sometimes three, groups in order to efficiently interact with the involved investigators at the site. The hydrology technical specialist visited boreholes UZ-4 and UZ-5 to discuss borehole instrumentation. Meanwhile, the geology technical specialist went to the Fran Ridge fracture pavement to examine the process of fracture mapping, and to the Sample Management Facility to view drill cores of the Paintbrush Tuff nonwelded (PTn) unit. One of the auditors visited the Hydrologic Research Facility to examine instrument calibration procedures and to follow-up on a CAR from a previous audit. The hydrology group visited additional boreholes on the second day, while the geology group traversed a section of Solitario Canyon looking at the lithology and fractures of the PTn. The NRC observer of the field audit accompanied the hydrology audit group on the first day and the geology audit group on the second day.

The checklist questions on both geology and hydrology could be traced directly to the reports and study plans. The nature of the questions posed by the technical specialists demonstrated a detailed review of the documents prior to the audit. Responses to most questions required a thorough knowledge of the investigations and could only be answered by report authors or other individuals involved in the data gathering.

The YM portion of the audit was observed by an NRC geosciences (technical) staff member. The Denver portion of the audit was observed by NRC QA staff only. Both technical and QA programmatic observations are presented below, grouped according to the technical area audited.

4.3.1 Stratigraphic Relations and Hydrologic Properties in the PTn

The geology audit sub-team visited several exposures of the PTn unit along the west face of YM in Solitario Canyon. The USGS Principal Investigators (PIs) provided a detailed walk-through of the many stratigraphic sub-units of the PTn, explaining their bases for dividing the units as they did. Several measured stratigraphic sections were observed, so the PIs were able to demonstrate lateral variations in the units. The technical specialist had few questions for the PIs while at the Solitario Canyon outcrops. Many checklist questions were answered the previous day while examining PTn drill core in the Sample Management Facility.

A DR was developed because the report of this activity was classified as not qualified but had been prepared under a quality affecting activity. The NRC staff agrees with the conclusion in this finding.

4.3.2 Fracture Character of the Paintbrush Tuff

The major exposures on which fractures were mapped in detail coincide with the measured stratigraphic sections visited for the PTn lithology study. Therefore, the technical specialist posed questions to both the lithology and fracture PIs at many exposures, with the majority directed to the fracture PI. The fracture PI discussed the rationale behind the selection of study areas, the identification of joint sets, and the mapping methodology. The PI was receptive to comments from the technical specialist on possible alternative procedures for quantifying fracture abundance. The technical specialist asked all checklist questions suitable for discussion in the field which related to the report on fracture character of the nonwelded Paintbrush Tuff. At fracture mapping site FS-3, the PI explained the difficulty in quantifying a network of small, abundant cooling joints below the welded, devitrified columnar zone at the base of the Tiva Canyon unit (top of the PTn thermomechanical unit). The discussion centered on how such fractures should be properly incorporated into a model for UZ hydrologic transport. The discussion indicates that the PI has a clear understanding of the importance of the work to hydrologic modelers, the end users of the product.

A DR was developed because the review of the technical report on this activity did not include verification that the report was consistent with its source data. The NRC staff agrees with the conclusion in this finding.

4.3.3 *In situ* Borehole Instrumentation and Monitoring

The hydrology audit sub-team visited boreholes UZ-4 and UZ-5 in Pagany Wash during the first day in the field. These boreholes, which are less than 50 meters apart, were equipped with instrumentation in June 1995. They share an instrument trailer which records *in situ* pneumatic pressure, temperature, and water potential. At the boreholes, the investigator explained the installation and workings of the measurement system as well as the rationale behind the design of the system. The investigator was very forthcoming with information, providing at times more than necessary for the auditor's purposes. After observing the equipment in the instrument trailer, the team returned to YM field offices, where most remaining checklist items were answered. Some checklist items were reserved for the Denver portion of the audit, when appropriate personnel were available to answer them.

During the Denver portion of the audit, interviews were held with the USGS PI and data analyst. The scope of the borehole investigation was discussed, as were report and data submittal schedules. The USGS staff pointed out that cold weather may cause difficulties with grouting in the borehole instrumentation. If the grout fails, the borehole may be lost for monitoring. This resulted in an audit team recommendation that temperature be considered when scheduling these types of activities.

The audit team reviewed the draft report, "*In situ* Borehole Instrumentation and Monitoring Data, October 25, 1994 through April 12, 1995," for boreholes NRG-6 and NRG-7a. This report is updated and published approximately every six months. Boreholes NRG-6 and NRG-7a were instrumented in October and November, 1994, to monitor *in situ* pneumatic pressure, temperature, and water potential. The primary purpose of the activity was to characterize the subsurface pneumatic system along the northern boundary of the repository in advance of any disturbance to the natural system that might result from construction of the North Ramp of the Exploratory Studies Facility. The primary focus of this portion of the audit was the USGS technical review and comment resolution process.

The Abstract section of the report stated that downhole sensors had been read every 3.5 to 5 hours. The readings are summarized in the report, and the actual time periods of the readings can be retrieved from the computer file which accompanies the report. Borehole data were transmitted daily to the hydrological research facility located at YM and then relayed to the data base at the USGS facility in Denver, CO. These data were then compiled in the draft report. The audit team noted that the transmittal letter for the last published report was signed but not dated. This was subsequently corrected during the course of the audit.

Comments for the review of this report prior to releasing it for publication are documented on comment forms. Comments are listed as either mandatory (which require a response/resolution) or nonmandatory (which are analogous to recommendations in that they are not necessarily incorporated into the final report). The comments were reviewed by the auditors for the nature and substance in complying with the requirements of the review process and were found acceptable.

As allowed by the QARD, this USGS activity relied completely on procedures and data record forms; scientific notebooks were not used. The auditors reviewed instrumentation plans and data packages for borehole NRG-7a, all which appeared comprehensive and complete.

Qualifications and position descriptions of personnel responsible for the review of this report were reviewed and found acceptable by the audit team. The audit team also found the review process for this report to be acceptable. The NRC staff agrees with the audit team's conclusion for this portion of the audit.

4.3.4 Fracture Network Model Development

Although this activity was not initially identified for audit, audit team discussions with field investigators lead to its audit. The development of the YM fracture network model is an important intermediate step in developing the site-scale hydrologic models. One and two dimensional fracture data from a number of sources are used with the FRACMAN code to generate simulations of the discrete three dimensional (3D) fracture network of YM. The model may be calibrated by comparing simulations to actual YM data and adjusting various parameters so that the simulations most closely resemble actual conditions. Hydrologic data may also be incorporated into the model.

USGS plans to use the discrete fracture network model to evaluate the use of simplified models, such as porous medium continuum models, in the site-scale 3D hydrologic model.

Since this activity was not included in the audit scope, the auditors performed only a brief overview of the activity. No deficiencies were identified by the auditors. The staff agrees with their assessment.

4.3.5 UZ Hydrologic Model Development

The geologic and hydrologic audit sub-teams joined in the audit of the conceptual and mathematical hydrologic model development. The focus of the audit was the report, "Preliminary Development of the LBL/USGS Three-Dimensional Site-Scale Model of Yucca Mountain, Nevada." The purpose of the work reported therein was to develop a three-dimensional model of moisture flow within the UZ at YM. The model is intended to 1) represent the variations of hydrological units between the ground surface and the water table, 2) be able to reproduce the effect of abrupt changes in hydrological units, and 3) include the influence of major faults.

Lawrence Berkeley Laboratories (LBL) was contracted by USGS to lead the mathematical modeling activity, which was controlled under the USGS QA program. The QA grading for this activity excluded scientific investigation controls. A previously issued YMQAD CAR addressed this apparently incorrect grading. The report and associated data have been classified as "Not Qualified." In addition, the TOUGH2 code used in this activity was not controlled under the QA program.

These and related issues were identified in a CAR and a DR (see section 4.7). Scientific notebooks were used for the activity, but were not brought from LBL for review during the audit. Discussion with LBL personnel suggested that these notebooks would not meet QA program requirements. LBL is being transitioned to a M&O team member rather than a USGS subcontractor after October 1, 1995, so future LBL activities will be controlled under LBL's QA program. At the time of the audit, DOE had not accepted LBL's QA program.

In October 1994, the (LBL) report of this activity was transmitted to DOE, and on December 12, 1994, the report was approved by DOE for distribution from a "programmatic and policy standpoint." A subsequent review of this report by DOE resulted in 47 technical comments, 37 of which were considered major. The audit team recognized this deficiency and documented it as part of a CAR (see Section 4.7). This condition appears to be repetitive, similar to conditions reported in CARs YM-95-045 and YM-95-046 written during the June 1995 YMQAD audit of USGS (Audit YM-ARP-12). The NRC staff is concerned that technical reviews conducted under the USGS QA program may not adequately verify the correctness, technical adequacy, completeness, accuracy, and compliance with established requirements of technical documents. This repetitive condition is listed as open item in the NRC Open Item Tracking System.

The auditors compiled a list of personnel involved in the areas audited in order to evaluate training, experience, and qualifications. To do this, they used the YMP-USGS Training Database. This system was established in 1989 by a USGS contractor to manage and store the YMP-USGS training information. This system appears to be an excellent and efficient method to store and retrieve training information from the database. Based on the NRC staff observation of this system, it is recommended that DOE consider adopting it for all participants. It has the capability to quickly print 1) the names of personnel assigned instruction for a particular subject; 2) training information required for an individual; 3) individual reading assignments; 4) reminder notices to complete required training; 5) any combination of personnel names and procedures; 6) information on what instruction is pending, overdue, or completed for each employee; and 7) what training requires instruction or "read only." A DR was developed because LBL personnel lacked training to applicable USGS procedures.

4.4 Audit Team Qualifications and Independence

The qualifications of the ATL and auditors were found to be acceptable in that they each met the requirements of QAAP 18.1, "Qualification of Audit Personnel."

The audit team members did not have prior responsibility for performing the activities they audited. The two Technical Specialists were M&O employees. While they were very familiar with the technical activities audited, they had no prior direct or oversight responsibility for the audited activities. The audit team members had sufficient independence to carry out their assigned functions without adverse pressure or influence. The audit team was well qualified in the QA and technical disciplines, and their assignments and checklist items were adequately described in the audit plan.

4.5 Review of Previous Audit Findings

A performance-based, technical audit of Quaternary faulting investigations performed by USGS was conducted in June 1995 (YM-ARP-95-12). Significant deficiencies were identified in the USGS technical review process. The corrective action for these deficiencies had not been completed at the time of this audit, so this audit did not address the open CARs. However, a surveillance by YMQAD was being conducted simultaneously with this audit to determine corrective action progress.

4.6 NRC Staff Findings

The QA programmatic and technical portions of the audit were conducted in a professional manner, and the audit team adequately evaluated activities and objective evidence. The audit was effective in determining the adequacy and degree of implementation of the USGS QA program as applied to UZ hydrologic model development activities.

Although previously recognized good auditing practices were not always followed, no adverse impacts resulted. The NRC staff did not observe any deficiencies in the audit process.

The NRC staff agrees with the preliminary YMQAD audit team findings.

4.6.1 Observation

The NRC staff is concerned that technical reviews conducted under the USGS QA program may not adequately assure the correctness, technical adequacy, completeness, accuracy, and compliance with established requirements of technical documents. This will be listed as an open item in the NRC Open Item Tracking System until satisfactorily resolved.

4.6.2 Recommendations

- The YMP-USGS Training Database appears to provide an excellent system for storing and retrieving training information, and DOE should consider adopting it for all participants.
- DOE should ensure through appropriate training that previously recognized good audit practices are followed.

4.7 Summary of YMQAD Audit Findings

The application of QA controls was determined to be effective except for the activity for developing the UZ hydrologic model. Based on the CAR and DRs identified, the effectiveness of QA controls for this modeling activity were indeterminate.

At the post-audit meeting the audit team presented the CAR, DRs, and PRs listed below.

4.7.1 CAR

UZ model development performed by LBL was not suitably controlled under the USGS QA program. Specifically, the TOUGH2 code was not controlled; the technical reviews of the LBL/USGS report LBL-37358/US-814, "Preliminary Development of the LBL/USGS Three-Dimensional Site-Scale Model of Yucca Mountain, Nevada," did not identify significant errors; the data package for this report was not updated after final comment resolution; LBL personnel lacked required training; and qualification records were incomplete.

4.7.2 DRs

- The report, "Stratigraphic Relations and Hydrologic Properties of the Paintbrush Tuff Nonwelded Hydrologic Unit, YM, Nevada," was classified as not qualified, but the activity had been classified as quality affecting.
- Technical reviews of the report, "Fracture Character of the Paintbrush Tuff Nonwelded Hydrologic Unit, Yucca Mountain, Nevada," did not include reviews for consistency with the supporting data.
- LBL personnel working on USGS UZ model development activities were not trained/indoctrinated as required.

4.7.3 PR

A calibration record did not identify the company that actually performed the calibration.

OPEN ITEM STANDARD REPORT

OITSID: TBD

LAST UPDATE: September 26, 1995

STATUS: Open

DATE RESOLVED:

TOPIC OF THE OPEN ITEM/UNCERTAINTY: Question the overall quality of the U.S. Geological Survey (USGS) technical reviews for correctness, technical adequacy, completeness, accuracy, and compliance with established requirements.

RESPONSIBLE BRANCH/SECTION: HLUR/HLW & Quality Assurance Section

ACTION AGENCY: DOE

IDENTIFICATION DATE: 15 September 1995

SOURCE TYPE: NRC Observation of DOE Audit YM-ARP-95-20 of USGS

SOURCE DOCUMENT: U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards, Division of Waste Management, Observation Audit Report OA-95-11

DOE ACTIVITY CODE/WBS NO.: 1.2.3.2.2.1.2/1.2.3.3.1.2.3

UNCERTAINTY TYPE: Technical

SPECIFIC TECHNICAL TYPE: Question regarding USGS's report review process.

OPEN ITEM TEXT: What policies or procedures will DOE require the USGS to implement to ensure acceptable quality of technical reviews of USGS documents?

RATIONALE/BASIS: The NRC staff participated as an observer of the DOE performance-based technical audit of the USGS in Denver, Colorado, from September 11-15, 1995 (Audit YM-ARP-95-20). The audit pertained to developing the unsaturated zone hydrologic model for Yucca Mountain. The main technical issue associated with the audit was the hydrologic characterization of structural features which significantly affect water and vapor movement. In addition, the audit team reviewed LBL-37358/UC-814, "Preliminary Development of the LBL/USGS Three-Dimensional Site-Scale Model of Yucca Mountain, Nevada." This report was transmitted to DOE in October 1994. On December 12, 1994, the report was approved by DOE for distribution from a "programmatic and policy standpoint." A subsequent review of this report by DOE resulted in 47 technical comments, 37 of which were considered major. The audit team recognized this deficiency and documented it as part of Corrective Action Request (CAR) YMQAD-95-C-051. This condition appears to be repetitive, similar to conditions in CARs YM-95-045 and YM-95-046 written during the YMQAD June 1995 audit of USGS (Audit YM-ARP-95-12). Based on this finding, the NRC staff questions the overall quality of the USGS technical reviews for

ENCLOSURE 2

correctness, technical adequacy, completeness, accuracy, and compliance with established requirements. This repetitive condition is listed as an Observation in Section 4.6.1 of NRC Observation Audit Report OA-95-11 and will be carried as an Open Item until satisfactory resolution.

RECOMMENDATIONS: The USGS response to DOE CARs YM-95-045, YM-95-046, and YMQAD-95-C-051 should address the policies or procedures USGS will implement to ensure the quality of USGS technical document reviews.

UNCERTAINTY RESOLUTION METHOD TYPE: Review USGS response to and DOE closeout of CARs YM-95-045, YM-95-046, YMQAD-95-C-051.

RATIONALE FOR UNCERTAINTY RESOLUTION METHOD SELECTION: None

HISTORY: September 11-15, 1995 - NRC noted the repeated deficiency during observation of DOE's audit of the USGS and documented concern via NRC Audit Observation Report OA-95-11.

CROSS REFERENCE

CITATION:

LARP (REVIEW PLAN) NUMBER: 10.0

REFERENCES:

U.S. NUCLEAR REGULATORY COMMISSION
OBSERVATION AUDIT REPORT OA-95-11
OF THE YUCCA MOUNTAIN QUALITY ASSURANCE DIVISION
AUDIT YM-ARP-95-20
OF THE U.S. GEOLOGICAL SURVEY

J. D. Brient for 10/19/95
Robert D. Brient (per telephone)
Center for Nuclear Waste
Regulatory Analyses

J. D. Brient for 10/19/95
William L. Belke (per telephone)
High-Level Waste Projects &
Quality Assurance Section
High-Level Waste & Uranium
Recovery Projects Branch
Division of Waste Management

Stephen M. McDuffie 10/19/95
Stephen M. McDuffie
Geosciences/Geotechnical
Engineering Section
Engineering and Geosciences Branch
Division of Waste Management

Reviewed and approved by:

John O. Thoma 10/30/95
John O. Thoma, Section Leader
High-Level Waste Projects &
Quality Assurance Section
High-Level Waste & Uranium
Recovery Projects Branch
Division of Waste Management

1.0 INTRODUCTION

Members of the U.S. Nuclear Regulatory Commission Division of Waste Management quality assurance (QA) and geosciences staff observed the U.S. Department of Energy (DOE), Office of Civilian Radioactive Waste Management (OCRWM), Office of Quality Assurance (OQA), Yucca Mountain Quality Assurance Division (YMQAD) audit of selected technical activities of the U.S. Geological Survey (USGS). The audit, YM-ARP-95-20, was conducted at Yucca Mountain (YM), Nevada on September 6-7, 1995, and at the USGS offices in Denver, Colorado from September 11-14, 1995.

The objective of the audit by YMQAD was to evaluate selected USGS scientific investigation activities and the quality of the resultant end products associated with the series of activities leading to the development of the unsaturated zone (UZ) hydrologic model of YM. These activities are identified in Section 4.1 of this report.

The NRC staff objective was to gain confidence that YMQAD and the USGS are properly implementing the requirements of their QA programs in accordance with the OCRWM Quality Assurance Requirements and Description (QARD: DOE/RW-0333P) and Title 10 of the Code of Federal Regulations (10 CFR), Part 60, Subpart G (which references 10 CFR Part 50, Appendix B).

This report addresses the effectiveness of the YMQAD audit and the adequacy of implementation of QA controls in the audited areas of the USGS QA program.

2.0 MANAGEMENT SUMMARY

This audit evaluated the implementation of the USGS QA program for activities associated with the flow of data from field geologic and hydrologic investigations through development of an UZ hydrologic model for YM. The State of Nevada was not represented at this audit.

The NRC staff determined that the audit was effective. The audit team found that the USGS QA program had been effectively implemented in the areas audited, with the exception of the activities associated with the UZ model development, which was indeterminate. The NRC staff agrees with these conclusions. One draft Corrective Action Request (CAR) was discussed at the exit meeting. It identified deficiencies in applying appropriate QA controls (including no software QA controls applied to the TOUGH2 code), inadequate personnel training, and inadequate technical reviews associated with the modeling efforts. In addition, three draft Deficiency Reports (DRs) and one draft Performance Report (PR) were initiated as a result of the audit.

3.0 AUDIT PARTICIPANTS

3.1 NRC

William Belke	QA Observer (Denver only)	
Stephen McDuffie	Technical Observer (YM only)	
Robert Brient	QA Observer (Denver only)	Center for Nuclear Waste Regulatory Analyses

3.2 DOE

Kenneth Gilkerson	Audit Team Leader (ATL)	YMQAD
Alan Rabe	ATL in Training	YMQAD
James Blaylock	Auditor	YMQAD
Ralph Rogers	Technical Specialist (Geology)	Civilian Radioactive Waste Management and Operating Contractor (M&O)
Bill Nelson	Technical Specialist (Hydrology)	M&O

4.0 REVIEW OF THE AUDIT AND AUDITED ORGANIZATION

This YMQAD audit of the USGS was conducted in accordance with OCRWM Quality Assurance Administrative Procedure (QAAP) 18.2, "Audit Program" and QAAP 16.1, "Corrective Action." The NRC staff observation of this audit was based on the NRC procedure, "Conduct of Observation Audits," issued October 6, 1989.

4.1 Scope of the Audit

The following technical areas concerned with developing the UZ model for YM were identified in the Audit Plan and were audited by the YMQAD audit team:

- Work Breakdown Structure (WBS) 1.2.3.2.2.1.1 - Vertical and Lateral Distribution of Stratigraphic Units Within the Site Area
- WBS 1.2.3.2.2.1.2 - Structural Features Within the Site Area
- WBS 1.2.3.3.1.2.3 - Percolation in the UZ - Surface Based Study
- WBS 1.2.3.3.1.2.9 - Site UZ Hydrologic Modeling

The following technical documents were audited by the YMQAD audit team:

- "Fracture Character of the Paintbrush Tuff Nonwelded Hydrologic Unit, Yucca Mountain, Nevada" - Undated Draft
- "Stratigraphic Relations and Hydrologic Properties of the Paintbrush Tuff Nonwelded Hydrologic Unit, Yucca Mountain, Nevada" - Draft transmitted to DOE by transmittal dated August 3, 1995
- "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" - Draft dated May 31, 1995
- "Preliminary Development of the LBL/USGS Three-Dimensional Site-Scale Model of Yucca Mountain, Nevada" - June 1995

The Key Technical Issue associated with the audit is "Hydrologic Characterization of Structural Features Which Significantly Affect Water and Vapor Movement."

4.2 Conduct Of Audit

The audit was performed in a professional manner and the audit team was well prepared. The audit plan identified this as a performance-based audit in which the evaluation of process effectiveness and product acceptability would be based upon 1) satisfactory completion of the critical process steps, 2) acceptable results and quality of the end product, 3) documentation that substantiates quality of products, 4) performance of trained and qualified personnel, and 5) implementation of applicable QA program elements.

In addition to being performance-based, this audit was also primarily a technical audit, the evaluations being lead by the hydrology technical specialist or the geology technical specialist along with a QA auditor. The five bases for the evaluations were generally addressed. However, technical examination of supporting documentation, particularly scientific notebooks and technical reviews, was limited. The NRC believes that performance-based technical audits should focus on all points in the process at which technical judgements are made. DOE OQA may need to reevaluate its approach to performance-based technical audits to ensure that all important technical and performance-related audit criteria are satisfied.

Caucuses were held daily between the audit team and the observers. Also, meetings of the ATL and USGS management (with an NRC observer present) were held daily to discuss the then-current audit status and preliminary findings.

The NRC has previously recognized a number of good audit practices through observation of OQA audits, such as tracking the status of potential findings and presenting findings based on requirements violated. However, these were not always followed during this audit. DOE should ensure through appropriate training that previously recognized good audit practices are followed.

4.3 Examination of Audited Areas

The audit followed the process of developing the UZ hydrologic model from geologic and hydrologic field investigations (audited at YM) through conceptual and mathematical model development (audited at Denver). The field portion of the audit focused on the methods of gathering the geologic data, which is later analyzed and input to the UZ hydrologic model framework. The audit team divided into two, sometimes three, groups in order to efficiently interact with the involved investigators at the site. The hydrology technical specialist visited boreholes UZ-4 and UZ-5 to discuss borehole instrumentation. Meanwhile, the geology technical specialist went to the Fran Ridge fracture pavement to examine the process of fracture mapping, and to the Sample Management Facility to view drill cores of the Paintbrush Tuff nonwelded (PTn) unit. One of the auditors visited the Hydrologic Research Facility to examine instrument calibration procedures and to follow-up on a CAR from a previous audit. The hydrology group visited additional boreholes on the second day, while the geology group traversed a section of Solitario Canyon looking at the lithology and fractures of the PTn. The NRC observer of the field audit accompanied the hydrology audit group on the first day and the geology audit group on the second day.

The checklist questions on both geology and hydrology could be traced directly to the reports and study plans. The nature of the questions posed by the technical specialists demonstrated a detailed review of the documents prior to the audit. Responses to most questions required a thorough knowledge of the investigations and could only be answered by report authors or other individuals involved in the data gathering.

The YM portion of the audit was observed by an NRC geosciences (technical) staff member. The Denver portion of the audit was observed by NRC QA staff only. Both technical and QA programmatic observations are presented below, grouped according to the technical area audited.

4.3.1 Stratigraphic Relations and Hydrologic Properties in the PTn

The geology audit sub-team visited several exposures of the PTn unit along the west face of YM in Solitario Canyon. The USGS Principal Investigators (PIs) provided a detailed walk-through of the many stratigraphic sub-units of the PTn, explaining their bases for dividing the units as they did. Several measured stratigraphic sections were observed, so the PIs were able to demonstrate lateral variations in the units. The technical specialist had few questions for the PIs while at the Solitario Canyon outcrops. Many checklist questions were answered the previous day while examining PTn drill core in the Sample Management Facility.

A DR was developed because the report of this activity was classified as not qualified but had been prepared under a quality affecting activity. The NRC staff agrees with the conclusion in this finding.

4.3.2 Fracture Character of the Paintbrush Tuff

The major exposures on which fractures were mapped in detail coincide with the measured stratigraphic sections visited for the PTn lithology study. Therefore, the technical specialist posed questions to both the lithology and fracture PIs at many exposures, with the majority directed to the fracture PI. The fracture PI discussed the rationale behind the selection of study areas, the identification of joint sets, and the mapping methodology. The PI was receptive to comments from the technical specialist on possible alternative procedures for quantifying fracture abundance. The technical specialist asked all checklist questions suitable for discussion in the field which related to the report on fracture character of the nonwelded Paintbrush Tuff. At fracture mapping site FS-3, the PI explained the difficulty in quantifying a network of small, abundant cooling joints below the welded, devitrified columnar zone at the base of the Tiva Canyon unit (top of the PTn thermomechanical unit). The discussion centered on how such fractures should be properly incorporated into a model for UZ hydrologic transport. The discussion indicates that the PI has a clear understanding of the importance of the work to hydrologic modelers, the end users of the product.

A DR was developed because the review of the technical report on this activity did not include verification that the report was consistent with its source data. The NRC staff agrees with the conclusion in this finding.

4.3.3 *In situ* Borehole Instrumentation and Monitoring

The hydrology audit sub-team visited boreholes UZ-4 and UZ-5 in Pagany Wash during the first day in the field. These boreholes, which are less than 50 meters apart, were equipped with instrumentation in June 1995. They share an instrument trailer which records *in situ* pneumatic pressure, temperature, and water potential. At the boreholes, the investigator explained the installation and workings of the measurement system as well as the rationale behind the design of the system. The investigator was very forthcoming with information, providing at times more than necessary for the auditor's purposes. After observing the equipment in the instrument trailer, the team returned to YM field offices, where most remaining checklist items were answered. Some checklist items were reserved for the Denver portion of the audit, when appropriate personnel were available to answer them.

During the Denver portion of the audit, interviews were held with the USGS PI and data analyst. The scope of the borehole investigation was discussed, as were report and data submittal schedules. The USGS staff pointed out that cold weather may cause difficulties with grouting in the borehole instrumentation. If the grout fails, the borehole may be lost for monitoring. This resulted in an audit team recommendation that temperature be considered when scheduling these types of activities.

The audit team reviewed the draft report, "*In situ* Borehole Instrumentation and Monitoring Data, October 25, 1994 through April 12, 1995," for boreholes NRG-6 and NRG-7a. This report is updated and published approximately every six months. Boreholes NRG-6 and NRG-7a were instrumented in October and November, 1994, to monitor *in situ* pneumatic pressure, temperature, and water potential. The primary purpose of the activity was to characterize the subsurface pneumatic system along the northern boundary of the repository in advance of any disturbance to the natural system that might result from construction of the North Ramp of the Exploratory Studies Facility. The primary focus of this portion of the audit was the USGS technical review and comment resolution process.

The Abstract section of the report stated that downhole sensors had been read every 3.5 to 5 hours. The readings are summarized in the report, and the actual time periods of the readings can be retrieved from the computer file which accompanies the report. Borehole data were transmitted daily to the hydrological research facility located at YM and then relayed to the data base at the USGS facility in Denver, CO. These data were then compiled in the draft report. The audit team noted that the transmittal letter for the last published report was signed but not dated. This was subsequently corrected during the course of the audit.

Comments for the review of this report prior to releasing it for publication are documented on comment forms. Comments are listed as either mandatory (which require a response/resolution) or nonmandatory (which are analogous to recommendations in that they are not necessarily incorporated into the final report). The comments were reviewed by the auditors for the nature and substance in complying with the requirements of the review process and were found acceptable.

As allowed by the QARD, this USGS activity relied completely on procedures and data record forms; scientific notebooks were not used. The auditors reviewed instrumentation plans and data packages for borehole NRG-7a, all which appeared comprehensive and complete.

Qualifications and position descriptions of personnel responsible for the review of this report were reviewed and found acceptable by the audit team. The audit team also found the review process for this report to be acceptable. The NRC staff agrees with the audit team's conclusion for this portion of the audit.

4.3.4 Fracture Network Model Development

Although this activity was not initially identified for audit, audit team discussions with field investigators lead to its audit. The development of the YM fracture network model is an important intermediate step in developing the site-scale hydrologic models. One and two dimensional fracture data from a number of sources are used with the FRACMAN code to generate simulations of the discrete three dimensional (3D) fracture network of YM. The model may be calibrated by comparing simulations to actual YM data and adjusting various parameters so that the simulations most closely resemble actual conditions. Hydrologic data may also be incorporated into the model.

USGS plans to use the discrete fracture network model to evaluate the use of simplified models, such as porous medium continuum models, in the site-scale 3D hydrologic model.

Since this activity was not included in the audit scope, the auditors performed only a brief overview of the activity. No deficiencies were identified by the auditors. The staff agrees with their assessment.

4.3.5 UZ Hydrologic Model Development

The geologic and hydrologic audit sub-teams joined in the audit of the conceptual and mathematical hydrologic model development. The focus of the audit was the report, "Preliminary Development of the LBL/USGS Three-Dimensional Site-Scale Model of Yucca Mountain, Nevada." The purpose of the work reported therein was to develop a three-dimensional model of moisture flow within the UZ at YM. The model is intended to 1) represent the variations of hydrological units between the ground surface and the water table, 2) be able to reproduce the effect of abrupt changes in hydrological units, and 3) include the influence of major faults.

Lawrence Berkeley Laboratories (LBL) was contracted by USGS to lead the mathematical modeling activity, which was controlled under the USGS QA program. The QA grading for this activity excluded scientific investigation controls. A previously issued YMQAD CAR addressed this apparently incorrect grading. The report and associated data have been classified as "Not Qualified." In addition, the TOUGH2 code used in this activity was not controlled under the QA program.

These and related issues were identified in a CAR and a DR (see section 4.7). Scientific notebooks were used for the activity, but were not brought from LBL for review during the audit. Discussion with LBL personnel suggested that these notebooks would not meet QA program requirements. LBL is being transitioned to a M&O team member rather than a USGS subcontractor after October 1, 1995, so future LBL activities will be controlled under LBL's QA program. At the time of the audit, DOE had not accepted LBL's QA program.

In October 1994, the (LBL) report of this activity was transmitted to DOE, and on December 12, 1994, the report was approved by DOE for distribution from a "programmatic and policy standpoint." A subsequent review of this report by DOE resulted in 47 technical comments, 37 of which were considered major. The audit team recognized this deficiency and documented it as part of a CAR (see Section 4.7). This condition appears to be repetitive, similar to conditions reported in CARs YM-95-045 and YM-95-046 written during the June 1995 YMQAD audit of USGS (Audit YM-ARP-12). The NRC staff is concerned that technical reviews conducted under the USGS QA program may not adequately verify the correctness, technical adequacy, completeness, accuracy, and compliance with established requirements of technical documents. This repetitive condition is listed as open item in the NRC Open Item Tracking System.

The auditors compiled a list of personnel involved in the areas audited in order to evaluate training, experience, and qualifications. To do this, they used the YMP-USGS Training Database. This system was established in 1989 by a USGS contractor to manage and store the YMP-USGS training information. This system appears to be an excellent and efficient method to store and retrieve training information from the database. Based on the NRC staff observation of this system, it is recommended that DOE consider adopting it for all participants. It has the capability to quickly print 1) the names of personnel assigned instruction for a particular subject; 2) training information required for an individual; 3) individual reading assignments; 4) reminder notices to complete required training; 5) any combination of personnel names and procedures; 6) information on what instruction is pending, overdue, or completed for each employee; and 7) what training requires instruction or "read only." A DR was developed because LBL personnel lacked training to applicable USGS procedures.

4.4 Audit Team Qualifications and Independence

The qualifications of the ATL and auditors were found to be acceptable in that they each met the requirements of QAAP 18.1, "Qualification of Audit Personnel."

The audit team members did not have prior responsibility for performing the activities they audited. The two Technical Specialists were M&O employees. While they were very familiar with the technical activities audited, they had no prior direct or oversight responsibility for the audited activities. The audit team members had sufficient independence to carry out their assigned functions without adverse pressure or influence. The audit team was well qualified in the QA and technical disciplines, and their assignments and checklist items were adequately described in the audit plan.

4.5 Review of Previous Audit Findings

A performance-based, technical audit of Quaternary faulting investigations performed by USGS was conducted in June 1995 (YM-ARP-95-12). Significant deficiencies were identified in the USGS technical review process. The corrective action for these deficiencies had not been completed at the time of this audit, so this audit did not address the open CARs. However, a surveillance by YMQAD was being conducted simultaneously with this audit to determine corrective action progress.

4.6 NRC Staff Findings

The QA programmatic and technical portions of the audit were conducted in a professional manner, and the audit team adequately evaluated activities and objective evidence. The audit was effective in determining the adequacy and degree of implementation of the USGS QA program as applied to UZ hydrologic model development activities.

Although previously recognized good auditing practices were not always followed, no adverse impacts resulted. The NRC staff did not observe any deficiencies in the audit process.

The NRC staff agrees with the preliminary YMQAD audit team findings.

4.6.1 Observation

The NRC staff is concerned that technical reviews conducted under the USGS QA program may not adequately assure the correctness, technical adequacy, completeness, accuracy, and compliance with established requirements of technical documents. This will be listed as an open item in the NRC Open Item Tracking System until satisfactorily resolved.

4.6.2 Recommendations

- The YMP-USGS Training Database appears to provide an excellent system for storing and retrieving training information, and DOE should consider adopting it for all participants.
- DOE should ensure through appropriate training that previously recognized good audit practices are followed.

4.7 Summary of YMQAD Audit Findings

The application of QA controls was determined to be effective except for the activity for developing the UZ hydrologic model. Based on the CAR and DRs identified, the effectiveness of QA controls for this modeling activity were indeterminate.

At the post-audit meeting the audit team presented the CAR, DRs, and PRs listed below.

4.7.1 CAR

UZ model development performed by LBL was not suitably controlled under the USGS QA program. Specifically, the TOUGH2 code was not controlled; the technical reviews of the LBL/USGS report LBL-37358/US-814, "Preliminary Development of the LBL/USGS Three-Dimensional Site-Scale Model of Yucca Mountain, Nevada," did not identify significant errors; the data package for this report was not updated after final comment resolution; LBL personnel lacked required training; and qualification records were incomplete.

4.7.2 DRs

- The report, "Stratigraphic Relations and Hydrologic Properties of the Paintbrush Tuff Nonwelded Hydrologic Unit, YM, Nevada," was classified as not qualified, but the activity had been classified as quality affecting.
- Technical reviews of the report, " Fracture Character of the Paintbrush Tuff Nonwelded Hydrologic Unit, Yucca Mountain, Nevada," did not include reviews for consistency with the supporting data.
- LBL personnel working on USGS UZ model development activities were not trained/indoctrinated as required.

4.7.3 PR

A calibration record did not identify the company that actually performed the calibration.

OPEN ITEM STANDARD REPORT

OITSID: TBD

LAST UPDATE: September 26, 1995

STATUS: Open

DATE RESOLVED:

TOPIC OF THE OPEN ITEM/UNCERTAINTY: Question the overall quality of the U.S. Geological Survey (USGS) technical reviews for correctness, technical adequacy, completeness, accuracy, and compliance with established requirements.

RESPONSIBLE BRANCH/SECTION: HLUR/HLW & Quality Assurance Section

ACTION AGENCY: DOE

IDENTIFICATION DATE: 15 September 1995

SOURCE TYPE: NRC Observation of DOE Audit YM-ARP-95-20 of USGS

SOURCE DOCUMENT: U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards, Division of Waste Management, Observation Audit Report OA-95-11

DOE ACTIVITY CODE/WBS NO.: 1.2.3.2.2.1.2/1.2.3.3.1.2.3

UNCERTAINTY TYPE: Technical

SPECIFIC TECHNICAL TYPE: Question regarding USGS's report review process.

OPEN ITEM TEXT: What policies or procedures will DOE require the USGS to implement to ensure acceptable quality of technical reviews of USGS documents?

RATIONALE/BASIS: The NRC staff participated as an observer of the DOE performance-based technical audit of the USGS in Denver, Colorado, from September 11-15, 1995 (Audit YM-ARP-95-20). The audit pertained to developing the unsaturated zone hydrologic model for Yucca Mountain. The main technical issue associated with the audit was the hydrologic characterization of structural features which significantly affect water and vapor movement. In addition, the audit team reviewed LBL-37358/UC-814, "Preliminary Development of the LBL/USGS Three-Dimensional Site-Scale Model of Yucca Mountain, Nevada." This report was transmitted to DOE in October 1994. On December 12, 1994, the report was approved by DOE for distribution from a "programmatic and policy standpoint." A subsequent review of this report by DOE resulted in 47 technical comments, 37 of which were considered major. The audit team recognized this deficiency and documented it as part of Corrective Action Request (CAR) YMQAD-95-C-051. This condition appears to be repetitive, similar to conditions in CARs YM-95-045 and YM-95-046 written during the YMQAD June 1995 audit of USGS (Audit YM-ARP-95-12). Based on this finding, the NRC staff questions the overall quality of the USGS technical reviews for

ENCLOSURE 2

correctness, technical adequacy, completeness, accuracy, and compliance with established requirements. This repetitive condition is listed as an Observation in Section 4.6.1 of NRC Observation Audit Report OA-95-11 and will be carried as an Open Item until satisfactory resolution.

RECOMMENDATIONS: The USGS response to DOE CARs YM-95-045, YM-95-046, and YMQAD-95-C-051 should address the policies or procedures USGS will implement to ensure the quality of USGS technical document reviews.

UNCERTAINTY RESOLUTION METHOD TYPE: Review USGS response to and DOE closeout of CARs YM-95-045, YM-95-046, YMQAD-95-C-051.

RATIONALE FOR UNCERTAINTY RESOLUTION METHOD SELECTION: None

HISTORY: September 11-15, 1995 - NRC noted the repeated deficiency during observation of DOE's audit of the USGS and documented concern via NRC Audit Observation Report OA-95-11.

CROSS REFERENCE

CITATION:

LARP (REVIEW PLAN) NUMBER: 10.0

REFERENCES: