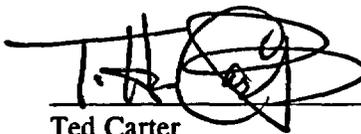


U. S. NUCLEAR REGULATORY COMMISSION
OBSERVATION AUDIT REPORT QA-98-01
OF THE YUCCA MOUNTAIN QUALITY ASSURANCE DIVISION
AUDIT LBNL-ARP-98-12
OF LAWRENCE BERKELEY NATIONAL LABORATORY


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ENCLOSURE

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, Yucca Mountain Quality Assurance Division (YMQAD) performance based audit of Lawrence Berkeley National Laboratory (LBNL) implementation of the OCRWM QA program. The audit, LBNL-ARP-98-12 was conducted on May 18-22, 1998, for work being performed at LBNL offices in Berkeley, California.

The objective of this performance based audit by YMQAD was to evaluate the implementation of the OCRWM program requirements and the technical activities associated with Work Breakdown Structure 1.2.3.3.1.2.4, and processing and control related to LBNL activities supporting Percolation in the Unsaturated Zone - Exploratory Studies Facility (ESF).

The NRC staff's objective was to gain confidence that YMQAD and the LBNL are properly implementing the requirements of the 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 (10CFR), 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 LBNL program.

2.0 MANAGEMENT SUMMARY

The NRC staff has determined that the YMQAD Audit LBNL-ARP-98-12 was useful and effective. The audit was organized and conducted in a professional manner. Audit team members were independent of the activities they audited. The audit team was well qualified in the QA and technical disciplines, and its assignments and checklist items were adequately described in the audit plan.

The audit team concluded that the OCRWM QA program had been satisfactorily implemented. Two deficiencies were reported at the exit meeting. The audit team also made two recommendations. The NRC staff agrees with the audit team conclusion, findings, and recommendations. The NRC staff determined that this audit was effective and that the OCRWM QA program implementation was adequate.

3.0 AUDIT PARTICIPANTS

3.1 NRC

William Belke	Observer (Yucca Mountain On-Site Representative)
Ted Carter	Observer (QA Specialist)
Jeff Ciocco	Observer (Technical Specialist)

3.2 DOE/YMQAD

Ed Opelski	Audit Team Leader (ATL)	YMQAD/Quality Assurance Technical and Support Services (QATSS)-MACTEC
Jim Blaylock	Auditor	DOE/YMQAD
Ken McFall	Auditor	YMQAD/QATSS-Science Applications International Corporation (SAIC)
Keith Kersch	Technical Specialist	M&O/SAIC
Steve Harris	YMQAD Temporary On-Site Representative	YMQAD/QATSS-SAIC

4.0 REVIEW OF THE AUDIT AND AUDITED ORGANIZATION

This YMQAD audit of LBNL was conducted in accordance with OCRWM Quality Assurance Procedure (QAP) 18.2, "Internal Audit Program" and QAP 16.1Q., "Performance/Deficiency Reporting." The NRC staff's 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 audit team conducted a performance based audit of activities supporting the following:

WBS 1.2.3.3.1.2.4, "Percolation in the Unsaturated Zone - Exploratory Studies Facility (ESF) Study," Milestone SP33PLM4, "Seepage Test Input to Unsaturated Zone Model, and Milestone SP33PBM4, "Draft Report Fracture Flow and Seepage Testing in the ESP."

Specifically, the Milestone Reports and their associated data inputs were evaluated for the critical process steps identified below:

Milestone SP33PLM4, "Seepage Test Input to Unsaturated Zone Model"

1. Scientific Investigation Planning
2. Identification, Traceability, and Control of Data
3. Data Analysis and Review
4. Control of Software
5. Control of Reference
6. Control of Scientific Notebooks
7. Control of Assumptions
8. Control of Measuring and Test Equipment
9. Independent Review of Results
10. Data Input to Genesis

Milestone SP33PBM4, "Draft Report Fracture Flow and Seepage Testing in the ESP"

1. Study Planning
2. Data Identification and Traceability
3. Status of Milestone

Several Key Technical Issues (KTIs) are associated with this audit. The two primary KTIs are the Unsaturated/Saturated Flow Under Isothermal Conditions and the Evolution of Near-Field Environment. The technical portion of this audit provided insight into DOE's program that will facilitate resolution of these issues.

4.2 Conduct of the Audit

The audit was performed in a professional manner and the audit team was well prepared and demonstrated a sound knowledge of the LBNL and DOE QA programs. Audit team personnel were persistent in their interviews, challenged responses when appropriate, and performed an acceptable audit. The audit plan identified this as a performance based audit in which the evaluation process effectiveness and product acceptability would be based on: 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 quality personnel; and 5) implementation of applicable QA program elements.

In addition to being performance based, this audit included technical evaluations on the Level 4 Milestone SP33PLM4, "Testing and Modeling of Seepage into Drift, Input of Exploratory Study Facility Seepage Test Results to Unsaturated Zone Models, January, 1998", and the future Level 4 Milestone SP33PBM4, "Draft Report, Fracture Flow and Seepage Testing in the ESF, due September, 1998."

The DOE audit team and NRC observers caucused at the end of each day. Also, meetings of the audit team and LBNL management (with an NRC observer present) were held each morning to discuss the current audit status and preliminary findings.

4.3 Timing of the Audit

The NRC staff believes the general timing of the audit was appropriate for YMQAD to evaluate the pertinent LBNL activities associated with the ongoing activities and implementation of the QA program. The YMQAD believed it would be prudent to perform this audit while percolation activities were still being conducted, to determine that this activity did not have any serious deficiencies.

4.4 Examination of QA Programmatic Elements

Since this was a performance based audit, the majority of the auditing effort focused on the technical aspects. The NRC staff observed that each of the auditors reviewed related documentation and interviewed a representative sample of LBNL personnel to determine their understanding of implementing procedures and processes. Checklists were used effectively and issues were provided beyond the checklists when appropriate. NRC observers were provided ample opportunities to provide comments and ask questions.

Training, education, and experience records were reviewed for personnel conducting scientific studies to assure such personnel were in compliance with their individual position descriptions. Objective evidence was provided and reviewed by the auditor and it was determined that all personnel were in compliance with the exception of objective evidence that scientists experience had been verified. This was previously identified and added to an existing deficiency report.

4.5 Examination of Technical Activities

As part of this performance based audit, a technical evaluation was conducted on the Level 4 Milestone SP33PLM4, "Testing and Modeling of Seepage into Drift, Input of Exploratory Study Facility Seepage Test Results to Unsaturated Zone Models, January, 1998", and the future Level 4 Milestone SP33PBM4, "Draft Report, Fracture Flow and Seepage Testing in the ESF, due September, 1998." The documents reviewed to conduct the technical portion of the audit are listed in Attachment 1.

The audit team's Technical Specialist prepared a comprehensive checklist to evaluate both milestones. LBNL personnel were interviewed, scientific and laboratory notebooks were reviewed, and references checked as part of the audit. The audit was greatly facilitated by the LBNL's staff cooperation and candidness.

The reports audited support Work Breakdown Structure element 1.2.3.3.1.2.4, Percolation in the Unsaturated Zone - Exploratory Studies Facility (ESF). The objective of this element is to conduct *in-situ* ambient cross-hole pneumatic and liquid-release niche seepage studies and alcove surface infiltration studies to evaluate fluid flow within the unsaturated zone at Yucca Mountain. The results will feed the site-scale and drift-scale models calibrated against on-going field test results in support of the Total System Performance Assessment for Yucca Mountain. The purpose of the niche drift-scale seepage tests is to better understand the drift seepage process, percolation fluxes, and capillary barrier system.

Milestone SP33PLM4 presented the Phase 1 preliminary test results and numerical model analysis of seepage into drifts. This included the test results of first seepage tests at Niche 3650 and sensitivity analysis of drift seepage with two and three-dimensional numerical models. The numerical models were then tested to predict the wetting-front arrival time of the planned infiltration test for Alcove 1. This report is the third technical report for the drift seepage testing and moisture analysis. Seepage and moisture studies are ongoing.

The purpose of SP33PBM4 is to present the results of the ongoing niche and alcove seepage studies. The following tasks, found in Master Scientific Notebook YMP-LBNL-JSW-6.0, comprise the work scope elements of SP33PBM4: (1) the drift scale seepage test, Phase 2; (2) field tests of flow propagation through heterogeneous and fractured Paintbrush nonwelded tuff (PTn), investigate fracture flow in the PTn, horizontal diversion of flow along interfaces between different subunits, and storage effects in the nonwelded unit; (3) fracture flow, fracture-matrix interaction, matrix imbibition test of middle nonlithophysal unit of Topopah Springs welded unit; (4) Alcove 1 and Alcove 7 testing, a collaboration with the United States Geological Survey (USGS) and Los Alamos National Laboratory (LANL); (5) laboratory studies to support percolation and seepage testing; and (6) drift to drift/borehole study.

The technical specialist investigated the validity of the steady state solution which is only valid if there is a fixed pressure at some radial distance and the validity of radial flow. It was determined the solution, using a modified Hvorslev permeability equation, provided the best "estimation" of permeability and not the definitive number. The skin effects from dry drilling were discussed with LBNL to determine if the permeability equation should be modified. LBNL stated the drilling techniques employed reduce the invasion of fractures from air drilling.

The audit team traced, through the Scientific and Laboratory Notebooks, the test and model permeability values in all tables. Sources of fracture permeability data, porosity and alpha were evaluated and traceable. The 2-orders of magnitude change in permeability from pre and post construction was found to be a reasonable conclusion. LBNL explained in detail how the results of the study will be used to improve the UZ flow model, and provide a design basis for repository seepage calculation.

The numerical model selection for the niche simulations was discussed to evaluate its representation of the natural physical system. LBNL justified the use of a simple, homogeneous, two and three-dimensional equivalent fracture continuum model as appropriate because of the short vertical distances of cross-hole tests and the unlikely matrix imbibition. Niche excavation rock samples

confirmed little matrix imbibition and supported the chosen model. As LBNL expected, the three-dimensional model produced less seepage into the drift because of fracture diversion around the crown of the niche.

The Alcove 1 numerical model predictive analysis was evaluated because it greatly overestimated the arrival time of the wetting front. LBNL explained the prediction was a preliminary evaluation of the system that used a low porosity, high permeability and high infiltration rates. LBNL is currently collecting field data from and interacting with the USGS and LANL to make revisions to the model. These revisions, as discussed at the May 20, 1998, Natural Environmental Program Operations Management Review Meeting, include selecting a new model called Multiple Interacting Continua which has capillary effects and matrix imbibition; adding additional model layers such as colluvium, caliche, calcite filled fractures and possibly shotcrete; making corrections for evapotranspiration and lateral diversion; and using measured permeability values. LBNL is commended for their efforts to assimilate the real-time field data and revise the unsaturated zone models.

No major technical deficiencies were detected in the work products related to seepage quantification and percolation flux by the audit team. The preliminary testing and modeling results in drift seepage and alcove studies should lead to a better understanding of the seepage process and capillary barrier system important to the potential repository performance. The audit team understood that the reports provide the foundation for future seepage analysis and modeling, but are preliminary and a work-in-progress.

4.6 Audit Team Qualification and Independence

The qualifications of the ATL and audit team members were found to be acceptable in that they each met the requirements of QAP 18.1, "Auditor Qualification." The audit team members did not have prior responsibility for performing the activities they audited.

The audit team members were prepared in the areas they were assigned to audit and were knowledgeable of applicable procedures. The checklist was adequately formulated and covered the subject matter well.

4.7 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 ATL was extremely effective in his daily presentation to the LBNL management and staff and providing guidance to the audit team.

The checklist questions provided a sound basis from which to conduct the performance based audit and reach an accurate conclusion on the percolation data collection process. Both the auditors and LBNL staff were knowledgeable in their respective disciplines. LBNL personnel appeared to be dedicated and committed to implement the DOE requirements.

DOE is considering placing a full time on-site representative at LBNL in order to actively and accurately provide additional guidance to implement DOE requirements. LBNL was receptive to this action since a DOE representative had been assigned to LBNL for a limited time frame. It was obvious to the NRC observers that the effort from this limited time frame provided valuable insight to LBNL personnel in order to better understand what is needed to produce an acceptable deliverable.

From a discussion with the Natural Environment Program Operations Manager, it was encouraging and understood that voluntary efforts are in process to initiate considerations from a "lessons learned" aspect, to incorporate applicable findings that surface in the recent "Vertical Slice Reviews of the UZ Flow Model" and "Total Systems Performance Assessment of the Waste Form Degradation and Solubility Limits." This effort will not be limited to LBNL but extended to all participants and should result in improved deliverables.

The NRC staff agreed with the technical findings of the DOE audit team. Other observations noted were as follows:

- Future audits should evaluate how the continued collection and analysis of niche and alcove data improve the unsaturated zone conceptual model and seepage effects.
- LBNL should continue to evaluate the effects of matrix imbibition, fracture filling, geochemistry, matrix saturation, modeling continuum, dripping sensitivities to ratio of injection rate to fracture conductivity, drift wall boundary conditions, and heterogeneity.
- It is unclear to an independent reviewer how work is planned, executed, and reported through the scientific notebook process and deliverable milestones. The Scientific Notebook Strawman Diagram for each milestone should be included in the Master Scientific Notebook.
- Coordination with other entities, such as the USGS and LANL, are not well documented in Scientific Notebooks and reports.
- Subsequent reports on the subject matter should include a chapter titled "(Planned) Future Work." The reader would then understand the full scope of the project and any future related deliverables.

4.8 Summary of YMQAD Findings

The application of QA controls was determined to be effective for the percolation data collection effort. The NRC staff agrees with this conclusion. The DOE audit team presented a summary of their findings and recommendations at the post audit meeting as listed below.

- The planning process appears weak based on difficulty to identify specific planning documents and their applicability.
- The Statement of Work received by LBNL did not appear to contain sufficient information to produce the milestone. The proposed revisions to LBNL procedures and response to an existing deficiency should assist in clarifying the above concerns. (*Recommendation*)
- Although identified and documented by LBNL the use of unqualified software should not be used at this stage of the project. (*Recommendation*)
- Technical procedures were inappropriately documented in scientific notebooks. Scientific notebooks were not reviewed during the technical review of milestone report. No verification of experience for scientists of technical reviews. This finding was added to an existing deficiency report.

- Wang, J.S.Y., R. C. Trautz, P. J. Cook, S. Finsterle, A. L. James, J. Birkholzer, C. F. Ahlers. 1998. Testing and Modeling of Seepage into Drift, Input of Exploratory Study Facility Seepage Test Results to Unsaturated Zone Models. Yucca Mountain Project Milestone SP33PLM4, Lawrence Berkeley National Laboratory, Berkeley, CA.
- Wang, J.S.Y., P. J. Cook, R. C. Trautz, R. Salve, A. L. James, S. Finsterle, T. K. Tolunaga, R. Solbau, J. Clyde. 1997. Field Testing and Observation of Flow Paths in Niches, Phase 1 Status Report of the Drift Seepage Test and Niche Moisture Study, Yucca Mountain Project Milestone SPC314M4, Lawrence Berkeley National Laboratory, Berkeley, CA.
- WBS Index and Dictionary - Annex 11 to the Project Management Plan, Volume 2, OCRWM-YMSC Project, Dictionary Document No. YMP/CC-00-01, Revision March 20, 1998, Red Stamped Control Copy, Las Vegas Document Control, Copy No 10355.
- YMP-LBNL-JSW-6.0, Master Scientific Notebook, Starting Date-May 12, 1997, WBS 1.2.3.3.1.2.4, ESF Moisture Monitoring-Drift Scale Seepage Test, Sections include Planning Summary, FY97 Initial Entry, FY98 Update, List of Procedures, List of Notebooks, and List of Documents, Principal Investigator-Joe Wang.
- YMP-LBNL-JSW-6.0, Reference Binder of Master Scientific Notebook, April 29, 1998, WBS 1.2.3.3.1.2.4, ESF Moisture Monitoring-Drift Scale Seepage Test, Field Controlled Copy No. 103366.1, Sections include Equipment in Active Testing, Samples Collected for Laboratory Testing, and Field Work Package FWP-WSF-96-004, Principal Investigator-Joe Wang.
- YMP-LBNL-JSW-6.A (Continuation of YMP-LBNL-JSW-6 and Master Scientific Notebook YMP-LBNL-JSW-6.0), Characterization of Yucca Mountain Percolation in the Unsaturated Zone-Exploratory Study Facility Study, Exploratory Study Facility Moisture Monitoring - Drift Seepage Test, WBS 1.2.3.3.1.2.4, Table of Contents: Notebook Introduction, Objectives, Scope and Test Sequence, Test Sequence, Pneumatic Injection Testing Procedures, and General Hydrological Data Acquisition and Control System, Principal Investigator-Joe Wang.
- YMP-LBNL-JSW-6, Scientific Notebook, Characterization Yucca Mountain Percolation I the Unsaturated Zone - Exploratory Study Facility, WBS 1.2.3.3.1.2.4, First entry May 12, 1997 - Air Injection, Liquid Release Test, and Niche Excavation, Last entry August 8, 1997, Principal Investigator-Joe Wang..
- YMP-LBNL-JSW-MAG1, Laboratory Notebook (Associated with Reference Binder YMP-LBNL-JSW-MAG1A), Percolation and Seepage, WBS 1.2.3.3.1.2.4, Fracture Matrix Flow Test/Equipment Calibration/Psychrometer Calibration, Owner-Margaret A. Guell, Principal Investigator-Joe Wang.

**YMP-LBNL-JSW-RS-1, Laboratory Notebook, Fracture Flow, Fracture-Matrix Interaction, Task:
Fracture-Matrix Flow Test, WBS 1.2.3.3.1.2.4, Starting date March 2, 1998. Owner-Salve Rohit,
Principal Investigator-Joe Wang.**

**YMP-LBNL-JSW-6.1, Laboratory Notebook, Moisture Monitoring in the Exploratory Study Facility
(phase 2) / Drift Seepage Test, Task-Moisture Monitoring in Alcove 1 and 7, WBS 1.2.3.3.1.2.4,
Starting Date September 01, 1997, Objective: assembly, installation, and monitoring of moisture
probes in alcoves 1 and 7, Owner-Salve Rohit, Principal Investigator-Joe Wang.**

**YMP-LBNL, Quality Implementing Procedures, Information Only Copy, Contains QA Policy Statement
dated July 15, 1995 and 14 Quality Implementing Procedures Updated on August 20, 1997.**