U. S. NUCLEAR REGULATORY COMMISSION

OBSERVATION AUDIT REPORT OAR-99-02

OF THE YUCCA MOUNTAIN QUALITY ASSURANCE DIVISION

AUDIT LBNL-ARP-99-06

OF LAWRENCE BERKELEY NATIONAL LABORATORY

05/12/99
Ted Carter, Quality Assurance Specialist
High-Level Waste and Performance
Assessment Branch
Division of Waste Management

05/12/99
Jeff Ciocco, Technical Specialist
High-Level Waste and Performance
Assessment Branch
Division of Waste Management

05/12/99
David Brooks, Section Chief
High-Level Waste and Performance
Assessment Branch
Division of Waste Management

05/18/99
Sandra Wastler, Section Chief
High-Level Waste and Performance
Assessment Branch
Division of Waste Management

Enclosure

9905280042 990524
PDR WASTE PDR
WM-11

1.0 INTRODUCTION

Members of the U.S. Nuclear Regulatory Commission (NRC) 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-99-06 was conducted on April 19-23, 1999, 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-99-06 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. Seven deficiencies were identified and corrected during the audit (CDA); therefore, no Deficiency Reports will be issued. Ten recommendations were offered as improvements/enhancements to the program, one will require a formal response. 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

Ted Carter	Observer (QA Specialist)
Jeff Ciocco	Observer (Technical Specialist)
Jack Spraul	Observer (NRC QA Task Force Member)

3.2 DOE

Al Williams	Observer (Office of Quality Assurance)	

3.3 DOE/YMQAD

Les Wagner	Audit Team Leader (ATL)	YMQAD/Quality Assurance Technical and Support Services (QATSS)-MACTEC
Emily S. Jensen	Audit Team Leader-In-Training	YMQAD/QATSS-MACTEC
Pat Auer	Auditor	YMQAD/QATSS-MACTEC
Harvey Dove	Technical Specialist	YMQAD/QATSS-Golder Associates
James Mattinoe	Auditor	YMQAD/QATSS-Science Applications International Corporation (SAIC)
Donna Sinks	Technical Specialist	M&O/SAIC

4.0 REVIEW OF THE AUDIT AND AUDITED ORGANIZATION

This YMQAD audit of LBNL was conducted in accordance with OCRWM Quality Assurance Procedures (QAP) 18.2, "Internal Audit Program," QAP 16.1Q., "Performance/Deficiency Reporting," and AP 16.2Q "Corrective Action and Stop Work." 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," Work Package 14012215M1, "Seepage Threshold Testing and 36C1 Analysis-SR-FY99." The audit also included a review of QA Program Elements directly related to the Work Package and evaluated the CRWMS M&O's implementation of the QA Program at LBNL to determine whether it meets the requirements and commitments imposed by the Office of Civilian Radioactive Waste Management (OCRWM). This was done by verifying implementation, adequacy, and determining the effectiveness of the QA Program in place, as well as verifying compliance with requirements. The Nuclear Regulatory Commission Issue Resolution Status Report, "Unsaturated and Saturated Flow Under Isothermal Condition" was also considered during the planning of the audit

Specifically, the Work Package activities and the associated data inputs were evaluated for the critical process steps identified below:

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. Interface Controls
11. Identification, Traceability and Control of Samples

The evaluation of process effectiveness and product acceptability was based upon:

- Satisfactory completion of the critical process steps
- Acceptable results and quality of the end product
- Documentation that substantiates quality of product
- Performance of trained and qualified personnel
- Implementation of applicable QA Program Elements

Applicable QA Program Elements to be reviewed during the compliance portion of the audit were:

1.0 Organization
2.0 QA Program
4.0 Procurement Document Control
5.0 Implementing Procedures
6.0 Document Control
7.0 Control of Purchased Items and Services
12.0 Control of Measuring and Testing Equipment
15.0 Nonconformances
16.0 Corrective Action
17.0 QA Records
Supplement I Software
Supplement II Sample Control
Supplement III Scientific Investigation
Supplement V Control of the Electronic Management of Data
Appendix C Mined Geologic Disposal System

The following QA Program Elements were also considered during the development of this audit plan and found not to applicable, since LBNL currently has no activities to which these elements apply:

3.0 Design Control
8.0 Identification and Control of Items
9.0 Control of Special Processes
10.0 Inspection
11.0 Test Control
13.0 Handling, Storage, and Shipping
14.0 Inspection, Test, and Operating Status
18.0 Audits
Supplement IV Field Surveying
Appendix A High-Level Waste Form Production
Appendix B Storage and Transportation

4.2 Conduct and Timing 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.

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

4.3 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.

4.4 Examination of Technical Activities

As part of this performance based audit, a technical evaluation was conducted on the following two chapters of an unpublished unsaturated zone report: (1) Trautz, R. C., J.S.Y. Wang, P.J. Cook, R. Salve, A.L. James, M.Q. Hu, S. Finsterle. 1998. Chapter 2, Flow Characterization and Drift Seepage Evaluation at the Niches. *In* Progress Report on Fracture Flow, Drift Seepage and Matrix Imbibition Tests in the Exploratory Studies Facilities, Revision 00, Not Approved; and (2) Oldenburg, C.M., J. Hinds, B.M. Freifeld, P.J. Cook, M.A. Guell, R. Salve, A.L. James, and J.S.Y. Wang. 1998. Chapter 4, Flow in nonwelded tuff: Preliminary results for the PTn at Alcove 4. *In* Progress Report on Fracture Flow, Drift Seepage and Matrix Imbibition Tests in the Exploratory Studies Facilities, Revision 00, Not Approved.

The audit team's Technical Specialist prepared a comprehensive checklist to evaluate the Milestone report. The Unsaturated and Saturated Flow Under Isothermal Conditions Issue Resolution Status Report was considered during the planning of the audit. Lawrence Berkeley National Laboratory (LBNL) personnel were interviewed, scientific and laboratory notebooks were reviewed, laboratory apparatus and sample identification and tracking were evaluated, and references checked as part of the audit. The audit was greatly facilitated by the LBNL's staff cooperation and candidness.

The reports support Work Breakdown Structure element 1.2.3.3.1.2.4, "Percolation in the Unsaturated Zone-Exploratory Studies Facility (ESF) Study," Work Package 14012215M1, Seepage Threshold Testing and 36Cl Analysis-SR-FY99." The Chapter 2 report evaluated drift-scale seepage processes at Niche 1 (construction station 35+66), Niche 2 (construction station 36+50), Niche 3 (construction station 31+07), and Niche 4 (construction station 47+88). The objective was to evaluate a capillary barrier effect could result from the construction of a cavity in the unsaturated rocks and to determine the seepage threshold flux. The purpose of the Chapter 4 report was to present the current status of work on the PTn Alcove 4 flow and diversion testing. To-date the work has included geologic modeling, numerical flow simulation, and permeability testing to design and plan for the liquid release phase of the project.

The technical specialist verified the accuracy of the mass of water released into the rock in a given test interval. The mass balance included the mass of the residual water and return line water. The instrumentation used during testing, including the timing device, was verified. Hysteresis of the fracture network was examined in some detail to understand if it was the result of wetting the available surface area to enhance sheet flow, saturating the void space represented by the fracture, or satisfying the imbibition requirements at the immediate fracture surface to at least a small matrix depth of the fracture network. The investigator satisfactorily explained the hysteresis effects as a combination of the above mentioned events.

The technical specialist investigated the applicability of the Philip analytical solution to the fractured rock network of the TSW niches. The analytical solution was originally developed for a "...steady downward unsaturated seepage field in deep, homogeneous, isotropic soil, alluvia, or porous rock." It was determined the solution was reasonable for the scale of testing conducting at the niches and the reasonableness of the results. It was recognized that the boundary conditions introduced by the excavation need to be taken into account in the interpretation of air permeability measurements, because the report documented an order of magnitude increase in air permeability measurements pre- and post-excavation.

The audit team traced through the available scientific and laboratory notebooks. Minor errors in the text and equations were reconciled during the audit. All data was found to be qualified as stated in the report. In particular, the laboratory experiments were performed on qualified samples and equipment. The auditors were able to track all of the data used in the report with the data located in the project's technical databases and scientific notebooks.

Liquid release tests conducted in the niches were transient pulses of water released into a zone where the formation had been dried out by ventilation through the ESF. It was noted that wetting history had a strong influence on seepage observed during these tests. Much more seepage and earlier arrival times were seen in tests conducted a few hours to a day apart. Based on these observations it was determined that two weeks should be allowed to elapse between tests so that the rock would have time to recover (i.e. dry out again). This experiment is supposed to represent seepage into the proposed repository that is expected to occur due to fairly steady percolation flux over thousands of years. However the question of why should a transient pulse injected into dry rock over a period of a few hours suffice to represent slow steady seepage into drifts, over a period of thousands of years, remained open at the end of the audit.

The technical specialist investigated the possibility of whether or not a vertical fractures would drip if the ambient percolation flux increases only a few mm/yr over present day conditions. The

straight line fit to data shown in figure 2.5.4-3 seems to indicate that the slope, and thus the alpha parameter, remains constant for the full range of permeabilities. If this is true then the capillary barrier effect and resulting capillary diversion would be minor for some of the individual vertical fractures. The investigator agreed this may occur with large vertical fractures. The range of the alpha parameters used in the seepage models did not include the value determined from the liquid release tests for the individual vertical fractures, even as an end-member. This remained an open question at the end of the audit. The alpha parameter of the exponential conductivity model (e.g. Philip, 1989) for the vertical fractures is determined to be 1/(9.8 Pa) = 1.02E-1 Pa^{-1} (section 2.5.5.1). The inverse of this alpha is related to capillary rise (equation 2.5-12). The seepage models use a van Genuchten alpha ranging between about 3E-4 to 3E-3 Pa^{-1} in the TSPA (Technical Basis Document Chapter 2) which is also related to capillary rise (Bodvarsson, et al., 1997 Site-Scale Unsaturated Zone Model, Chapter 7 equation 7) and the base case is a van Genuchten alpha of about 1.0E-3 Pa^{-1} (section 2.8).

4.5 NRC Staff Findings

The NRC staff agreed with technical findings of the audit team, and add the following as open technical questions and comment, that were not resolved during the audit.

Questions:

- Are the niche tests sufficient to represent slow steady seepage of the unsaturated zone conceptual model?
- Why does the range of alpha parameters used in the seepage models not include the value determined from liquid release tests for individual vertical fractures, at least as an end-member?
- The capillary barrier hypotheses may be minor for some individual vertical fractures with only slightly greater percolation flux than present day. Will this implied possibility be treated in numerical models of seepage processes?

Comment:

- The simulation conclusions of 1 mm/yr as the appropriate ambient percolation rate may be grounded in the poor fitting van Genuchten parameters.

4.6 Audit Team Qualification and Independence

The qualifications of the Audit Team Leader, Audit Team Leader-In-Training, 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 Summary of YMQAD Findings

Overall results of Audit LBNL-ARP-99-06:

- The critical process steps evaluated were found to be adequate and effective for the ongoing activities associated with seepage studies at the Niches and Flow in Nonwelded Tuff.
- Out of the applicable program elements evaluated, seven deficiencies were identified and corrected during the audit (CDA); therefore, no Deficiency Reports will be issued.
- Ten recommendations were offered as improvements/enhancements to the program, one will require a formal response.
- Overall, significant improvements were noticed since the last audit

CDAs:

QA Program

- Missing dates on two reading assignments.
- Employment/experience form had incorrect header.

Document Review

- Document Review/comment forms contained comment resolution added after project manager sign off (non-mandatory comments).

Control of M&TE

- Equipment Log Book did not contain a calibration due date. Info was contained in Scientific Notebook.

QA Records

- TOC for QIP-2.1 Review Package was inaccurate.
- Document Control Action requests and controlled document instructions not submitted to RPC.
- Software Configuration status accounting monthly reports and user requests were not submitted to RPC as nonpermanent QA records.

RECOMMENDATIONS:

Requires Response:

- Clarify records submittal requirements in QIPs and TIPs for individual records and records packages to be submitted to RPC.
- Include role of planning and technical preparers in QIP-5.2 for Master Planning Documents; show where coordination with other organizations in planning effort is conducted.
- Ensure staff understands difference between mandatory and non-mandatory review comments.
- Provide adequate time frame between document approval and effective date to allow for training and distribution of controlled document.
- Coordinate with OQA Representative to determine if potential conditions adverse to quality warrant formal documentation in accordance with AP-16.1Q.
- Evaluate QIPs, TIPs and MPDs for appropriate personnel to be on controlled

distribution because of the recent revision of QIP 6.0, effective 4/19/99.

- Clarify use of, and reference of sample and equipment log books in scientific notebooks and quality implementing procedures.
- Standardize the reporting of LBNL calibrations. This would be user friendly for meeting the requirements of the soon to be issued YAP-12.3Q, Vontrol of M&TE.
- Ensure consistent citations for data reeferences.
- Consider NRC Acceptance criteria in future testing for drift seepage.