Los Alamos National Laboratory
Quality Assurance Manual
for the
Yucca Mountain Site Characterization Project

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LANL-YMP-QP-04.4, R0	Procedure for Commercial-Grade Items and Service	R
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LOS ALAMOS NATIONAL LABORATORY QUALITY ASSURANCE PROGRAM PLAN FOR THE YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Effective Date 03/07/91

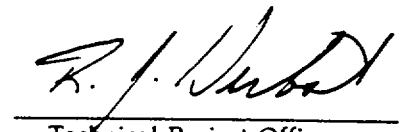
Quality Assurance Project Leader
S. L. Bolivar

3/1/91.
Date

Technical Project Officer
R. J. Herbst

3/6/91
Date

Los Alamos National Laboratory is committed to the highest standards of technical excellence. Well-planned programs for maintaining and improving quality are essential elements of this commitment. This Quality Assurance Program Plan has been prepared as an explicit statement of this commitment as it applies to our work in support of the Yucca Mountain Site Characterization Project. Each person working in support of the Project shall be indoctrinated in the requirements of this Plan; activities shall be planned, implemented, and maintained as it requires; and all work shall follow its implementing procedures.



Technical Project Officer
Richard J. Herbst

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ACRONYMS

AP	—	Administrative Procedure
DOE	—	Department of Energy
DP	—	Detailed Technical Procedure
EES	—	Earth and Environmental Sciences Division
HLW	—	High-Level Waste
LANL	—	Los Alamos National Laboratory
NBS	—	National Bureau of Standards
NCR	—	Nonconformance Report
NRC	—	Nuclear Regulatory Commission
OCRWM	—	Office of Civilian Radioactive Waste Management
PI	—	Principal Investigator
PMP	—	Project Management Plan
PQM	—	Project Quality Manager
PRA	—	Probabilistic Risk Assessment
QA	—	Quality Assurance
QADD	—	Quality Assurance Division Director
QAL	—	Quality Assurance Liaison
QALA	—	Quality Assurance Level Assignment
QAO	—	Quality Assurance Officer
QAP	—	Quality Assurance Plan
QAPL	—	Quality Assurance Project Leader
QAPP	—	Quality Assurance Program Plan
QAS	—	Quality Assurance Support
QP	—	Quality Implementing Procedure
RPC	—	Records Processing Center
SQAP	—	Software Quality Assurance Plan
TPO	—	Technical Project Officer
WBS	—	Work Breakdown Structure
YMP	—	Yucca Mountain Site Characterization Project (formerly NNWSI)

1.0 ORGANIZATION

1.1 Management

Management responsibility for the Yucca Mountain Site Characterization Project (YMP) at Los Alamos National Labaoratory (LANL) is assigned to group EES-13. The Project Office uses a Work Breakdown Structure (WBS) to describe and relate the work of the Project. Individual WBS elements are assigned to the Project participants, which include LANL. EES-13 plans and manages the LANL efforts required to support work assignments made by the Project Office. The EES-13 Group Leader shall be YMP Technical Project Officer (TPO). Any delegation of this responsibility by the EES-13 Group Leader shall be in writing.

1.2 Quality Assurance Program

A Quality Assurance (QA) Program shall be established and shall be described in a Quality Assurance Program Plan (QAPP). Major changes may be made to the QAPP. However, these changes shall be subject to the Project Office's approval. Implementation of the requirements of the QAPP shall be accomplished through quality implementing procedures (QPs). The QPs shall ensure that standard practice and objective evidence (records) attesting to compliance with the requirements result from their use.

1.3 Quality Assurance Organization

The overall LANL YMP organization is described in Figure 1-1. Duties and responsibilities of all personnel shall be described in position descriptions prepared by supervisors. The position description shall also document the minimum education and experience required for each position. QA responsibilities follow.

1.3.1 Technical Project Officer

The TPO shall be responsible for the development of the overall quality program. The TPO shall approve the QAPP, QPs, implementing technical and administrative procedures, and technical information products.

1.3.2 Project Leaders

The Project Leaders are responsible for understanding and implementing the LANL YMP QA Program in their areas of responsibility, as applicable, on a day-to-day basis. This shall include developing quality, technical, or administrative procedures as appropriate; participating in audits and surveillances; reviewing and approving technical information products in accordance with the appropriate procedures; and ensuring that support staff is trained to the appropriate QP and technical or administrative procedures.

1.3.3 Coordinators

Coordinators are responsible for understanding and implementing the LANL YMP QA Program in their areas of responsibility, as applicable, on a day-to-day basis. This shall include developing quality, technical, or administrative procedures as appropriate; participating in audits and surveillances; and ensuring that support staff is trained to the appropriate QP and technical or administrative procedures.

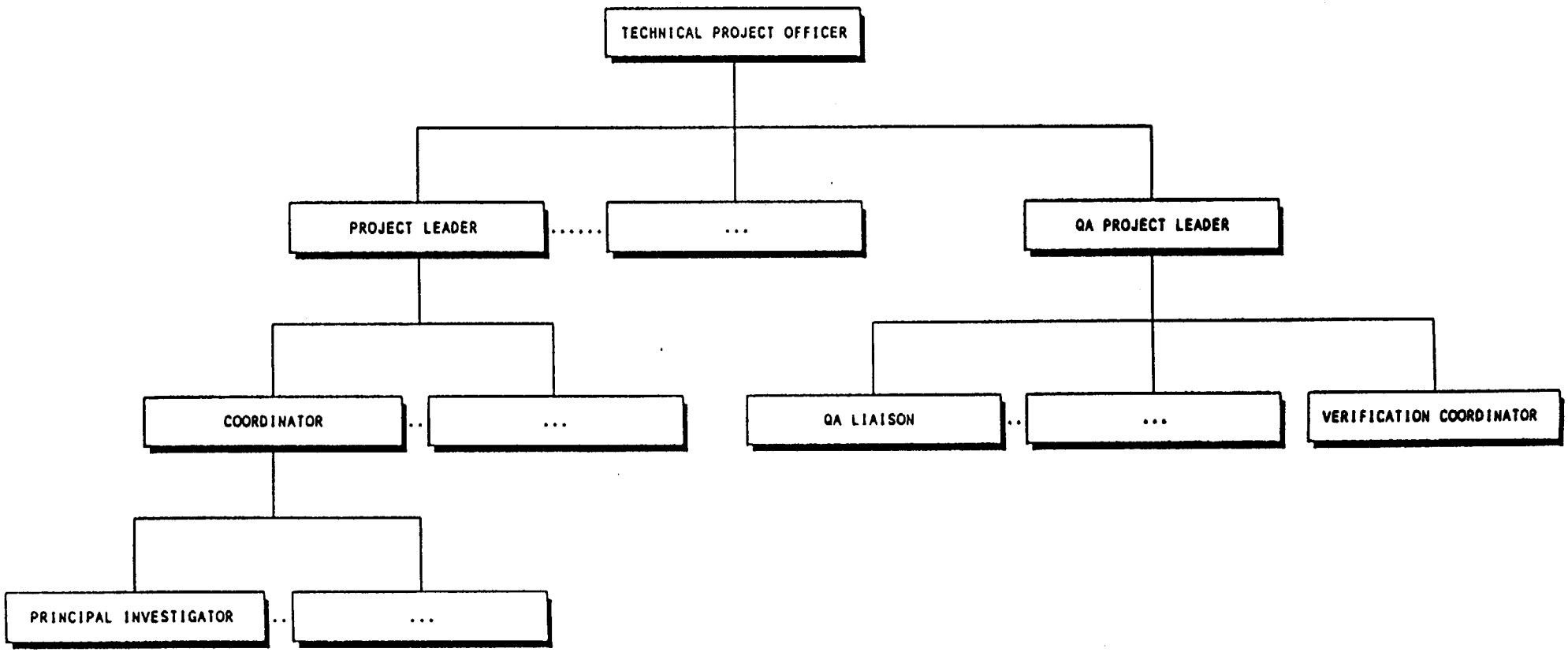

Figure 1-1. YMP Organization at LANL.

1.3.4 Principal Investigators

Principal Investigators (PIs) are responsible for understanding and implementing the LANL YMP QA Program for scientific investigation activities, as applicable, on a day-to-day basis. This shall include developing quality and technical procedures; participating in audits and surveillances; and ensuring that support staff is trained to the appropriate QPs and technical procedures.

1.3.5 Dedicated Quality Assurance Positions

The following positions are assigned QA responsibilities only.

1.3.5.1 Quality Assurance Project Leader

Responsibility for the development of a Quality Assurance Program Plan (QAPP) and implementation of the QAPP shall be assigned to an EES-13 staff member who shall be titled QA Project Leader (QAPL). The QAPL shall approve the QAPP and the QPs. The QAPL shall report administratively to the TPO. Verification of the overall quality program shall be assigned to a subcontractor. The verification subcontractor shall report to the QAPL. The verification subcontractor shall survey and audit the YMP work at LANL. The verification subcontractor shall review the QPs proposed by LANL. Additional duties in connection with administration of the QA Program may be assigned to a subcontractor at the discretion of the QAPL. Such assignments shall be documented.

The QAPL is authorized to resolve disputes regarding the interpretation of quality requirements or their applicability. Disputes that cannot be satisfactorily resolved by the QAPL shall be decided by the TPO. Decisions by the TPO may be appealed by the QAPL to the LANL Quality Assurance Officer (QAO) or the YMP QA Division Director (QADD). QA-related decisions by the LANL QAO or the YMP QADD are final.

1.3.5.2 Quality Assurance Liaison

LANL organizational units (divisions or groups) and subcontractors with twelve or more full-time-equivalent employees assigned to the YMP shall employ a Quality Assurance Liaison (QAL). Group EES-13 shall employ a QAL at-large who shall serve all smaller units. The QAL shall facilitate implementation of the quality assurance program within the unit. The QAL shall report programmatically to the QAPL. Personnel assigned as QALs shall not have other duties or responsibilities that prevent or conflict with those in connection with their QAL assignment. Additional duties and responsibilities as well as the education and experience required of personnel assigned as QALs shall be described in position descriptions prepared by the QAPL.

1.3.5.3 Verification Coordinator

The Verification Coordinator shall report directly to the QAPL. The Coordinator shall be part of the subcontractor verification organization and be fully responsible for directing the internal audit and survey program and ensuring that the assigned audit staff is trained to the appropriate LANL implementing procedures.

1.4 Achievement, Maintenance, and Verification of Quality

Quality shall be achieved and maintained by those performing the actual work, i.e., the line organizations. Quality achievement shall be verified by persons not directly responsible for performing

the work, i.e., the QA verification staff. Allegations of inadequate quality or disputes over quality requirement conformance shall be resolved in accordance with the LANL implementing procedure for quality conflict resolution.

1.5 Interface Between Participant Organizations

Interfaces are defined as exchanges or shared technical requirements of work and organizational liaison with ongoing work. When more than one participant organization is involved in activities affecting quality, the responsible line organization shall clearly define the interface in accordance with the LANL implementing procedure. This interface between LANL and other participants shall be through the TPO. All interfaces between LANL and the Project Office are through the TPO as defined in the implementing procedures.

For internal interfaces at LANL, this document describes the various duties and responsibilities of the overall LANL YMP organization to effectively manage the LANL YMP. No further action or implementation procedures are necessary. Interfaces between LANL and its subcontractors shall be defined in procurement documents resulting from the use of the procurement implementation procedures.

2.0 QUALITY ASSURANCE PROGRAM

2.1 Basic Requirements of the LANL YMP Quality Assurance Program

LANL's QA Program consists of the LANL QAPP and QPs. The LANL QAPP and QPs will be prepared by the LANL YMP QA and technical staff to comply with the most current revision of the YMP Quality Assurance Plan (QAP). The QAPP will be submitted to the QADD for review prior to implementation. When the LANL QAPP is submitted to the Project Office for review, a checklist based on the YMP QAP is included. After the QAPP is reviewed by the QADD and after comments and revisions are resolved, the documents will be approved by the PQM; the approved QAPP will be issued. After internal LANL review, comment, and approval (pursuant to Section 6 of this QAPP), QPs will be issued for use.

Changes to the LANL YMP QAPP may be proposed by any LANL YMP staff by submitting the proposal, in writing, to the LANL YMP QAPL. Proposed changes will be evaluated by the QAPL, to ensure compliance with YMP quality requirements, and will either be approved or disapproved. Approved changes will be submitted to the TPO for review and either be approved or disapproved. Disapproved changes will be returned to the originator with a description of why the proposed change was disapproved. If the TPO approves the proposed change, the change will be submitted to the Project Office QADD for review. If the QADD approves the change, then the QAPP will be revised and redistributed.

Revisions to any portion of a section requires redistribution of that entire section, including the signature page, indicating approval of the revision; the title page, indicating the revision of the document; and the table of contents, indicating the revision of the section.

This QAPP complies with the requirements of the Project Office QAP. The LANL YMP and subcontractor activities shall be carried out in accordance with this QAPP and QPs, which shall be applied in a way that is consistent with the importance of the activity.

As part of the QA Program, management above or outside of the QA organization shall regularly receive information as to the scope, status, adequacy, compliance, etc., of the QA Program. Readiness reviews, as appropriate, shall be performed and shall apply to major scheduled and/or planned activities that could affect quality. Readiness reviews shall be used in verifying that specified prerequisites and programmatic requirements have been identified before a major activity is started.

This QAPP applies to LANL QA Level I and II activities associated with the YMP, including nuclide migration studies; geochemistry; mineralogy; petrology studies; and planning for the exploratory shaft construction, technical direction, and testing program. LANL also provides assistance in accordance with this QAPP to other Project organizations in areas of specialized expertise as directed by the Project Office.

The activities covered by this QAPP shall be delineated in the LANL YMP WBS, which is maintained at the TPO's office. The QAPP includes the following basic provisions for activities affecting quality.

- Activities affecting quality shall be planned and documented to ensure a systematic approach. Planning results in the documented identification of methods and organizational responsibilities. Planning shall begin as early as practicable and shall be completed no later than the start of those activities.
- Activities affecting quality shall be accomplished under controlled conditions, which include the use of appropriate equipment, the maintenance of environmental conditions suitable for accomplishing the activity, the use of formal procedures for the given activity, and the assurance that all prerequisites for the given activity have been satisfied.

- Procedures for activities affecting quality shall specify any equipment and technical skills necessary to achieve the required quality for that activity.
- Procedures for activities affecting quality shall specify the means to verify quality by peer reviews (Project Office directed), technical review, survey and audit, or a combination of these.
- All LANL YMP personnel performing activities affecting quality shall be indoctrinated and/or trained in both technical and QA requirements of their assigned task. QA auditors are trained and qualified in accordance with YMP requirements. The certification of YMP personnel shall be documented.
- LANL YMP management shall assess the adequacy and implementation of this QAPP regularly and shall formally report the results on an annual basis to the Project Manager and PQM.
- LANL participants are responsible for interfaces with other major YMP participants as specified in the WBS and outlined in Section 1 of this QAPP.

2.1.1 Verification of the Quality Assurance Program Plan

The QAPL or his appointee shall conduct internal audits of all phases of the application of this QAPP for all LANL YMP activities affecting quality. These internal audits shall assess the continuing implementation, effectiveness, compliance, and adequacy of the QA Program. LANL shall prepare a QP for the review of suppliers' QA Programs. The procedure shall make provisions for the assignments of responsibility for review and approval of the supplier QA Program. The procedure shall identify documents for review and approval and the documentation of results. Reviews shall be recorded on checklists that specify the criteria and that indicate conformance or nonconformance.

2.1.2 Use of Data Not Generated under Quality Assurance Controls

For use in licensing activities, the QA Program for the LANL YMP provides some data or data interpretations that were not generated under a program that meets the requirements of 10 CFR 60, Subpart G. Specific methods for acceptance of this information will be in YMP AP-5.9Q, "Acceptance of Data and Data Interpretations Not Developed under the Yucca Mountain Site Characterization Project QA Program." Once accepted, these data shall be classified as "primary data" for licensing purposes. A LANL QP shall be prepared to implement these requirements (see also Appendix G).

2.1.3 Approach to Quality Assurance

The YMP uses a graded approach to QA that recognizes the differences between items and activities that may or may not have an effect on radiological health, safety, and waste isolation. The graded approach is designed to ensure that each item or activity is assigned a QA level consistent with its potential impact on, or importance to, radiological health and safety; waste isolation; nonradiological health and safety; achievement of Department of Energy (DOE) mission objectives; NRC licensing requirements; and operability and maintainability of the repository, including its costs and schedules. The assignment is accomplished by deliberate planning and selective application of QA requirements on the items or activities to be performed. The degrees of QA to be applied depend on the item function, complexity, consequence of failure, reliability, replicability of results, and economic considerations. LANL or the Project Office shall identify QA levels for all items and activities affecting quality that are associated with site characterization, facility and equipment construction, facility operations, performance confirmation, permanent closure, and decontamination and dismantling of surface facilities. QA levels assigned by LANL are subject to Project Office approval before work begins on the item or activity.

2.2 Application of Graded Quality Assurance

LANL YMP activities will be graded in accordance with the Project Office guidance, and the resulting grading reports will be submitted to the Project Office for review and approval. Graded activities will be those defined in the YMP controlled documents YMP/90-55, Q-List; YMP/90-56, Quality Activities List; and YMP-90-57, Project Requirements List. Grading for activities at lower WBS levels will be conducted in accordance with a LANL QP. The resulting grading report will be submitted to the Project Office for their information.

2.3 Quality Assurance Activities

LANL shall perform an overview of the QA activities of all organizations, including LANL subcontractors and suppliers of services. The overview shall include a review of the existing QA Program before a contract is awarded; method for documenting review and approval action; and a survey(s) and/or audit(s) to verify the adequacy of, and compliance with, the QA Program during the contract period.

Following LANL's QPs for procurement, the statement of work may require, if appropriate, that the supplier or subcontractor have or create a QA Program equivalent to the LANL QAPP or, at the supplier's option, use the QAPP. These procedures shall identify the types of documents to be submitted for review and approval, assign responsibility for review, and identify the methods for documenting review and approval action.

2.4 Management Assessment

Management assessments shall be conducted at least annually to verify that the QA Program is being effectively implemented; that the system and management controls established to achieve and ensure quality are effective; that the resources and personnel provided to the QA Program are adequate; and that personnel are trained to the QA requirements of the program. These assessments shall be performed and reported in accordance with LANL QPs, which shall include the minimum requirements for planning, organizing, performing, and documenting the results.

The assessment procedure shall specify that results be analyzed for quality trends and that reports and recommendations be tracked. Management outside or above the QA organization shall be responsible for the management assessment activity. Copies of the LANL management assessment report shall be transmitted to the YMP Project Manager and PQM.

2.5 Personnel Indoctrination and Training Procedures

LANL shall establish requirements for the selection, indoctrination, and training of personnel performing or verifying activities that affect quality. Position descriptions shall establish minimum personnel qualifications and the necessary indoctrination or training or both before a person starts work on activities that affect quality. In addition, personnel performing activities that specifically require certification by applicable codes and standards (e.g., lead auditors, Appendix F) shall be certified in accordance with those codes and standards.

2.5.1 Position Descriptions and Evaluation of Personnel Qualifications

For the YMP, LANL requires position descriptions that specify and generally describe the activities performed for each YMP personnel position. Requirements for formal education and experience shall be stated in these YMP position descriptions for personnel performing and verifying activities that affect quality. The relevant education, experience, and training of personnel shall be verified. The initial capabilities of an individual shall be based on an

evaluation of his education, experience, and training and compared to those established for the position. The YMP personnel proficiency evaluations shall be performed and documented at least annually by managers or supervisors responsible for the activities performed. Proficiency evaluations may be performed in conjunction with periodic or day-to-day employee performance evaluations.

2.5.2 Indoctrination

Personnel assigned to perform activities affecting quality shall first be indoctrinated to the purpose, scope, methods of implementation, and applicability of the following documents (including revisions and changes) as they relate to the work to be accomplished:

- QAPPs,
- implementing procedures and work instructions (applicable to the individual's responsibilities),
- regulations, and
- Project-level documents.

Indoctrination may be effected through the use of a mandatory reading list, classroom presentations, video presentation, or other instructional methods.

2.5.3 Training

Before being assigned activities affecting quality (i.e., assignments where it is deemed necessary to develop and demonstrate initial proficiency), personnel shall undergo training to gain the required proficiency. This training shall encompass the principles, techniques, and requirements of the activity. Such training may include classroom sessions, workshops, on-the-job training, or other instructional methods.

2.5.4 Training and Certification for Auditor

Requirements for training and certification of auditors, lead auditors, and technical observers are addressed in Appendix F of this QAPP.

2.5.5 Records

YMP personnel files shall contain the indoctrination and training records, position descriptions, annual certification forms, initial qualification evaluations for work on the LANL YMP, and supervisors' documentation of the annual YMP proficiency evaluations. These documents shall be retained as QA records.

Records of these activities will include the objective and content of the training or indoctrination dates the name of the instructor, attendees, results of any YMP proficiency evaluations, the initial evaluation, and any other applicable information and shall be maintained as lifetime QA records. The evaluation documents for the proficiency of YMP personnel shall include the name of the employee, the name of the evaluator, evaluation results, date, and activities covered by the evaluation.

The evaluation documents for the qualification of YMP personnel shall include the verification and evaluation of employee education, experience, and training as compared with those required for the position.

3.0 SCIENTIFIC INVESTIGATION CONTROL AND DESIGN CONTROL

3.1 Scientific Investigation Control

3.1.1 Preparation of Scientific Investigation Planning Documents

Scientific investigations affecting quality shall be planned and documented to ensure a systematic approach. Before the start of any scientific investigation, the responsible PI shall develop a scientific investigation planning document for that investigation that outlines the work to be performed and delineates the instructions for complying with the requirements of the defined scope of work. Scientific investigations categorized as site characterization activities, as defined in the Nuclear Waste Policy Act (as amended), shall use study plans as the scientific investigation planning document. The requirements for the format and content of study plans are included in Appendix K of this QAPP. QA level assignments (QALAs) will be made in accordance with administrative procedures (APs).

At a minimum, the scientific investigation planning document shall include or reference the following:

- a description of the work to be performed, with the scope and proposed methodology clearly defined;
- a discussion of the purpose for the work;
- identification of who is to perform the work;
- instructions on how to perform the work (i.e., using the applicable technical procedures or scientific notebooks); and
- schedule requirements.

The description of the work to be performed in the scientific investigation shall include references to any applicable regulations, requirements, performance criteria, key issues, issues, information needs, planning documents for higher-level scientific investigations, or WBS items for which the work is performed. The study plan will be the controlling document, will describe the scope of work, and will identify the controls to be used. The description shall identify the known factors and concerns that are important for the planning or the performance of the scientific investigation. Any previous work used in support of the scientific investigation shall be described, including identification of the QA levels or QA controls under which that work was performed. Note: This requirement does not apply to study plans. The scientific investigation planning document shall be attached to documents containing a level of detail that will enable an independent reviewer to determine that the appropriate QA level has been applied to the investigation. LANL scientific investigation planning documents that are approved and in place with approved QALAs will remain in place and active until they are superseded or withdrawn by LANL or the Project Office.

3.1.2 Quality Assurance Level Assignment

Once a scientific investigation planning document has been developed, the associated QALA for each of the activities and built-to-order items in that plan shall be prepared. It may be necessary in some cases to assign QA levels to the supporting activities and built-to-order items in previously prepared plans. Therefore, the QALA is not itself a part of the plans, even though it normally accompanies those plans and goes through the same review and approval process.

3.1.3 Review and Approval of Scientific Investigation Planning Documents

The organization that develops a scientific investigation planning document shall conduct a technical review of it to ensure that

- fabrications, installations, modifications, inspections, experiments, and tests have been incorporated;
- the scientific investigation can be conducted as specified;
- time, resources, and training are sufficient to accomplish the work in accordance with the specified sequential progression of operations; and
- the overall measures to be employed preserve the quality of the work.

The technical review shall be performed by any qualified individual other than those who developed the original scientific investigation planning document. The originator's immediate supervisor may perform the review if the supervisor is the only other technically qualified individual and if the need is documented and approved in advance by the QAPL. The results of the technical review and the resolutions of any comments by the reviewers shall be documented and shall become part of the QA records as prescribed in the QP for document review.

The scientific investigation planning document shall be reviewed pursuant to LANL procedures. The TPO or his designee shall then forward the scientific investigation planning document to the Project Office for review and approval by the appropriate branch chief. The scientific investigation planning document will be returned to the TPO upon completion of the Project Office review and approval cycle. Study plans shall also be reviewed and approved by OCRWM prior to implementation. A peer review of the scientific investigation planning document shall be conducted if the Project Office deems it necessary. In the event that any completed research reports or activities are required to have a peer review, they will be referred to the Project Office by the TPO.

All changes in the scientific investigation planning document shall go through this same review and approval process. If modified work is not within the scope of the study plan or the scientific investigation planning documents and

- is not repeatable or
- could potentially impact the waste isolation capability of the site or
- could interfere with other site characterization activities,

then approval shall be obtained from an appropriately qualified reviewer. The PI is responsible for evaluating the effects of such changes on the associated QALAs. Minor changes in the scientific investigation planning document limited to inconsequential editorial corrections need not go through the same review and approval process as a technical change must. However, minor changes shall be reviewed and approved by the appropriate Project Leader and concurred with by the QAPL before issue. A file of the minor changes made in scientific investigation planning documents shall be maintained in the appropriate Resident File.

3.1.4 Scientific Investigation Data Interpretation and Analysis Documents

Interpretation and analysis shall be performed in a planned, controlled, and documented manner that shall provide details that will be sufficient for a technically qualified individual to review, understand, and verify the analysis without recourse to the originator. Documentation shall include purpose, method, assumptions, input, references, and qualitative and quantitative units. These documents shall be legible and in a form suitable for reproduction, filing, and retrieval. Calculations shall be identifiable by subject, originator, reviewer, and date.

Documentation of interpretation and analysis shall include or reference the following:

- a definition of the objective;
- a definition of input and sources;
- a listing of applicable references;
- results of literature searches, or other background data;
- identification of assumptions;
- identification of any computer calculation, including computer type, program name, revision, input, output, evidence of program verification, and the bases of application to the specific problem; and
- signatures and dates of review and approval by appropriate personnel.

3.1.5 Use of Computer Programs

Computer programs used to support a license application shall be subject to the requirements of LANL procedures for software QA requirements (See Subsection 3.3, Appendix H of this QAPP, and NUREG-0856.)

3.1.6 The Use of Scientific Notebooks Versus the Use of Detailed Technical Procedures

There are two kinds of documentation that can be used for the QA documentation and control of scientific work: the scientific notebook and the detailed technical procedure (DP). Scientific notebooks generally are used by qualified individuals who are largely guided by professional judgment and who use trial and error methods in their work. A DP generally is used when a qualified individual performs repetitive work that is not guided by professional judgement and does not involve trial and error methods. DPs shall be required when deviation from a prescribed sequence of actions endangers the validity of the results. Bound notebooks, logbooks, or appropriate forms shall be used to document the performance of DPs and the control over all other aspects of the work. Documentation of scientific work, i.e., experiments and research, shall be performed to provide a written record of the experiment or research.

3.1.6.1 Detailed Technical Procedures

DPs, together with other supporting documents or notebooks, shall be used whenever the work is repetitive and is performed by individuals who may not be directly supervised by a PI. Modifications of the technical aspects of DPs shall be approved by an appropriately qualified reviewer. DPs shall be developed, reviewed, changed, or modified in accordance with the requirements given in Section 5 of this QAPP.

Acceptance or rejection criteria of the performance of a DP, including required levels of precision and accuracy, shall be provided by the organization responsible for the scientific investigation.

DPs used for scientific investigations shall provide for the following as appropriate:

- objectives, methods and/or characteristics to be tested or observed.
- prerequisites such as calibrated instrumentation, adequate and appropriate equipment and instrumentation, suitable and controlled environmental conditions, and provisions for data collection and storage. For activities of long duration, specific provisions shall be established and documented for instrumentation whose calibration interval is shorter than the expected duration of the activity. Such provisions shall be designed to ensure validity of data throughout the scientific investigation.

- mandatory verification points.
- acceptance and rejection limits and criteria, including required levels of precision and accuracy. (Note: "Accept/reject criteria" means those features or characteristics of a DP that make it possible to determine whether that the results were produced by work that was performed properly and according to the DP. A data acquisition task produces output that, in itself, cannot be characterized as acceptable or unacceptable. However, the task of acquiring the data is acceptable if all specified prerequisites were met and the work was accomplished in the specified manner. In that instance, the "accept/reject criteria" are simply the conditions and methods stated in the DP.)
- methods of documenting or recording data and results, including precision and accuracy.
- methods of data reduction.
- provision for ensuring that prerequisites have been met.
- special training or qualification requirements for personnel performing the scientific investigation.
- personnel responsibilities.

DPs shall be complete to the extent that another qualified individual may, at a later date, repeat the procedure and gather similar results.

The potential sources of uncertainty and error in technical implementation procedures that must be controlled and measured to ensure that scientific investigations are well controlled shall be identified. Parameters that need to be measured and/or controlled to minimize such uncertainties or error and to ensure adequate control shall be addressed explicitly in test procedures.

For instrumentation and/or equipment used in data collection, consideration shall be given to whether failure or malfunction of the instrumentation during scientific investigation will be detectable, either during data collection or by examination of the data. Where ability to detect such failure or malfunction is questionable, procedures will include any special provisions for equipment and instrumentation configuration, installation, and use that can further reduce risk of undetectable failure or malfunction.

Changes to field and laboratory procedures associated with scientific investigations shall be controlled to ensure that such changes are subsequently documented and verified in a timely manner by authorized personnel. Any procedural deviation encountered during activities shall be documented, reported, and evaluated for significance.

3.1.6.2 Scientific Notebooks

Bound scientific notebooks may be used with other appropriate documents to record scientific investigations and experiments. A competent technical reviewer will sign the notebook. When using notebooks, documentation shall be sufficiently detailed so that another qualified scientist can trace the investigation and confirm the results or repeat the experiment and achieve similar results without recourse to the PI. Notebooks must be maintained as stipulated in LANL QPs.

When recording results of scientific investigations in notebooks, investigators shall include the acceptance/rejection criteria for the process of generating the data.

Initial Entries

Initial entries are considered to be the "general" procedure. Modifications to this "general" procedure shall be recorded in the notebook in process entries.

Where appropriate, before initiation of the experiment or research, the following entries shall be made or referenced, as applicable:

- the title of the experiment or research;
- the name of the qualified individual(s) performing the experiment or research;
- a description of the experiment's objective(s);
- equipment and materials to be used during the experiment or research, including any necessary design or fabrication of experimental equipment and any needed characterization of starting material;
- calibration requirements;
- the dated signature of the individual(s) making the initial entries;
- special training or personnel qualification requirements;
- documentation of suitable and controlled environmental conditions; and
- the potential sources of uncertainty and error in scientific investigations which must be controlled and measured to ensure that the investigations are well controlled.

In-Process Entries

In-process entries shall include or reference, as applicable:

- the date and name of the individual making the entry;
- provisions for ensuring that prerequisites have been met;
- a description of the experiment or research attempted, including the detailed step-by-step process followed (reference may be made to the use of a DP if one is used);
- a description of any conditions that may adversely affect the results of the experiment or research;
- identification of samples used and any additional equipment and materials not included as part of the initial entries;
- all data taken during the experiment and a brief description of the results, including notation of any unexpected results;
- any deviations from the planned experiment or research;
- any interim conclusions reached, as appropriate; and
- when final results have been reached, a summary of the outcome of the experiments or research, including a discussion of whether the experiment's objectives as outlined in the initial entries were achieved. The final results and summary shall be included in a report. Reference to the report shall be made in the notebook. The report shall become part of the QA records for the activity.

Final Entries

The final entries of experiments or research require, as a minimum, the signature of the investigator and a competent technical reviewer as described in the LANL implementing procedure.

3.1.6.3 Logbooks

A logbook is associated with a specific activity, an operating device, or sample location. Logbooks and entries thereto shall be controlled according to a LANL QP. Logbooks may also be used to note any pertinent data concerning their assignment, including such entries as data runs and results, calibration runs and results, downtimes, and sample withdrawals.

3.1.7 Interface Control

Internal and external scientific investigation interfaces and efforts shall be coordinated between LANL participants and other YMP participating organizations. Interface controls shall include the assignment of responsibility and the establishment of procedures among and within participating organizations for the review, approval, release, distribution, and revision of documents involved with scientific investigations and interfaces. Interfaces within LANL shall be coordinated according to LANL QPs. Interfaces between scientific investigations, or between a scientific investigation and any other YMP activities, shall be coordinated among YMP participants in accordance with LANL QPs. Interfaces between LANL and suppliers shall be controlled in accordance with QPs established in the procurement documents. The transmittal of information or items (including samples of natural or man-made materials) across interfaces shall be documented according to LANL policy.

Ongoing field or laboratory investigations, where several organizations may be involved, shall be identified to preclude inadvertent interruption and to ensure operational compatibility. Such identification shall be clearly evident on the location. Field surveys shall identify the location of the scientific investigation.

3.1.8 Verification of Scientific Investigation

3.1.8.1 Verification Planning

Planning and performance of verification activities shall be accomplished and documented using LANL QPs. Verification procedures shall provide for the following:

- identification of characteristics and activities to be verified;
- a description of the method of verification;
- identification of the individuals or groups responsible for performing the verification;
- acceptance and rejection criteria;
- identification of required procedures, drawings, and specifications (including revisions used);
- recording identification of the verifier and the results of the verification.

The LANL QA organization shall perform surveys (according to Section 18 of this QAPP) of all scientific investigations, as deemed appropriate for the purposes and the complexity of the work. The QA verification team for a scientific investigation shall consist of one or more technically qualified individuals who are familiar with the scientific investigation planning document and one or more QA personnel. This verification team shall determine the timing and number of surveys.

3.1.8.2 Verification Hold Points

Mandatory verification hold points shall be established as necessary during preparation of the DPs. When such hold points are established, work may not proceed without the specific consent of the QAL. These hold points shall be indicated in appropriate documents controlling the activity. Consent to waive any specified hold point shall be documented before work can be continued beyond the designated hold point.

3.1.8.3 Reporting Independence of Personnel

Verifications shall be performed by personnel who do not report directly to the immediate supervisor(s) who is (are) responsible for performing the activity being verified. If these personnel are not part of the formal QA organization, they shall have sufficient authority, access to work areas, and organizational freedom to (1) identify quality problems; (2) initiate, recommend, or provide solutions to quality problems through designated channels; (3) verify implementation of solutions; and (4) ensure that further processing, delivery, installation, or use is controlled until proper disposition has occurred. When the persons or organizations who perform the verification activities are not part of the formal QA organization (i.e., part of line management), then the QA organization shall overview and monitor the activity.

3.1.9 Reports, Conclusions, and Recommendations

Technical review of the results and documentation of scientific investigations shall be accomplished in accordance with LANL QPs that specify that all final reports shall be submitted to the Project Office for review and approval.

3.1.10 Close-Out Verification

Because a considerable period of time may pass before data from a completed scientific investigation are used in the licensing process, close-out verification shall be performed upon completion of any scientific investigation to ensure that the QA records for that investigation are adequate and complete. Close-out verifications shall be performed by a team consisting of technically qualified personnel as well as by QA personnel.

3.2 Design Control

LANL, at present, has direct responsibility for design control activities. This section is included for LANL design control activities and for pass-through to LANL subcontractors. (Currently this function is performed by EG&G for design of the integrated data system.)

3.2.1 General

The design shall be defined, controlled, and verified. The term "design" refers to specifications, drawings, design criteria, and performance requirements for the natural and engineered components of the repository system. Design control measures shall be applied to conceptual designs, or parts thereof, which may at a later time become part of the final design. Design information and design activities refer to the data collection and analyses used in supporting design development and verification. This includes general plans and technical procedures for data collection and analyses and related information such as test results and analyses. Plans for data collection and analyses shall be complete before performing the data collection and analysis activities. Data collection activities resulting from scientific investigations can produce design input. Data analysis includes the initial step of data reduction as well as broad systems analyses

(such as performance assessments), which integrate many other data and analyses of individual parameters.

It is the policy of the YMP that the completed or final design of a facility or item evolves from a sequential order of design activities (or phases) wherein each phase becomes more detailed in nature than the preceding phase. For organizations responsible for design, the number and length of design phases required to complete the design of any particular item or facility may vary according to the timeliness and availability of pertinent information and the complexity of the item or facility. However, producing a unified facility design depends on the coordinated interfaces among all YMP design organizations.

3.2.1.1 Quality Assurance Level Assignment

All design phases shall be assigned a QA level before execution in accordance with the methods specified in LANL QPs.

3.2.1.2 Qualification of Personnel

Personnel performing design work shall be oriented, trained, and qualified in accordance with the requirements of Subsection 2.4 of this document. Instructions, procedures, and drawings for design work shall comply with the requirements of Section 5 of this document.

3.2.1.3 Peer Review

A peer review is an acceptable method of design verification for design activities or design documents that are beyond the state-of-the-art. These design activities or design documents may involve or specify the use of untried testing and design analysis procedures and methods or detailed technical criteria and requirements that do not exist or are being developed. (See also Appendix J of this QAPP.)

The peer review shall meet the requirements of Subsection 3.5 of this QAPP.

3.2.2 Design Input

Applicable design input (such as site characterization data, criteria letters, design bases, performance and regulatory requirements, codes, standards, manufacturer's design data, and quality standards) shall be identified and documented, and their selection shall be reviewed and approved by the responsible design organization and QA organization. The purpose of this QA review, at the input stage, is to ensure that the documents are prepared, reviewed, and approved in accordance with documented procedures and QA requirements. Changes in approved design input, including the reason for the changes, shall be identified, documented, reviewed, approved, and controlled by the responsible design organization. Design input (see Appendix B) shall be specified and approved on a timely basis to the level of detail necessary to permit design activities to be carried out in a correct manner and to provide a consistent basis for making design decisions, accomplishing design verification measures, and evaluating design changes.

3.2.3 Design Analysis

Design analysis shall be planned, controlled, and documented in sufficient detail, including purpose, method, assumptions, design input, references, and units, to enable a technically qualified person to review, understand, and verify the analysis without recourse to the originator. These documents shall be produced in a form suitable for reproduction, filing, and

retrieval. Calculations shall be identified by subject, including structure, system, or component; originator; reviewer; and date.

3.2.3.1 Documentation of Design Analysis

Documentation of design analysis shall include the following:

- a definition of the objective of the analysis;
- a definition of the design input and its sources;
- a listing of applicable references;
- results of literature searches and other background data;
- identification of assumptions and an indication of those that require verification as the design proceeds;
- identification of any computer calculation, including computer type, program name, revision, input, output, evidence of program verification, and the bases of application to the specific problem; and
- signatures and dates of review and approval by appropriate personnel, including QA personnel. The purpose of this QA review, at the analysis stage, is to ensure that the documents are prepared, reviewed and approved in accordance with documented procedures and QA requirements.

3.2.3.2 Use of Computer Programs

Computer programs used to support a license application shall be verified and controlled as specified in QPs for software QA requirements (see Subsection 3.3).

3.2.4 Design Verification

3.2.4.1 Identification and Documentation

The organization responsible for a design shall verify the adequacy of the design in a timely manner, according to the design control measures and shall identify and document the verification method used, the results of the verification, and the personnel involved.

3.2.4.2 Timing of Verification

Verification of the adequacy of the design shall be performed before its release for procurement, manufacture, construction, or release to another organization for use in other design activities. In cases where this timing cannot be met, the portions of the design that have not been verified shall be identified and controlled. In all cases, the verification shall be completed before the component, system, or structure is used.

3.2.4.3 Extent of Verification

The extent of the design verification necessary shall be a function of the importance to the safety of the item under consideration, the complexity of the design, the degree of standardization, and the similarity with previously proven designs. The verification process need not be duplicated for identical designs that have been verified in accordance with the requirements of this section. However, if new design inputs affect the application of standardized or previously proven designs, those designs shall be verified for each application. Known problems affecting the standardized or previously proven designs and their effect on other features shall be considered. The original

design and associated verification measures shall be referenced in the files of subsequent applications of the design.

3.2.4.4 Changes in Verified Designs

Changes in previously verified designs shall require further verification steps, including the evaluations of the effects of those changes on the overall design.

3.2.4.5 Persons Performing Verification

Design verification shall be performed by any certified individual(s) or certified group(s) other than those who performed the original design. Those individuals qualified to verify designs include

- individuals or groups from the originator's organization,
- individuals or groups from other organizations contracted for this purpose, and
- the originator's supervisor, providing all of the following requirements are met:
  - — the supervisor is the only individual in the organization competent to perform verification;
  - — the supervisor did not establish the design input used, specify the design approach, or rule out certain design considerations; and
  - — the rationale for satisfying the two requirements above shall be documented and approved by management superior to the supervisor (the QAPL must concur with the rationale).

3.2.4.6 Methods of Design Verification

Design verification shall be accomplished by design reviews, alternate calculations, qualification testing, and/or peer reviews. LANL QPs shall establish responsibilities, areas and features to be verified, pertinent considerations, and the extent of documentation needed.

Design Reviews

Design reviews shall be detailed critical reviews meant to ensure that the design is correct and satisfactory. At a minimum, the reviewers shall consider the items below and document the results of such deliberations.

- Have the design inputs been selected correctly?
- Have the assumptions used to perform the design activity been adequately described and are they reasonable?
- Upon completion, are the assumptions reverified when necessary?
- Has an appropriate design method been used?
- Have the design inputs been incorporated into the design correctly?
- Is the design output reasonable as compared with the design input?
- Have the design input and verification requirements needed by interfacing organizations been specified in the design documents or in supporting procedures or instructions?
- Have the computer programs used for analysis been identified and verified in accordance with the methods specified in LANL QPs and DPs?

Alternate Calculations

Alternate calculations may be used to determine the adequacy of the original analyses. The use of alternate calculations requires a technical review of the assumptions, inputs, and computer programs or other methods used in the calculation.

Qualification Tests

Qualification tests that involve physical testing of systems, structures, or components may be used to verify the adequacy of a design or a specific design feature. Where design adequacy is to be verified by qualification tests, the tests shall be identified in the design document. The following stipulations shall apply to the use of qualification tests.

- The test configuration shall be clearly defined and documented.
- Testing shall demonstrate adequacy of performance under conditions that simulate the most adverse design conditions. Operating modes and environmental conditions in which the item must perform satisfactorily shall be considered in determining the most adverse conditions.
- Other features of the design shall be verified by other means when the test is intended to verify only specific design features.
- Test results shall be documented and evaluated by the organization responsible for the design to ensure that test requirements have been met.
- If qualification testing indicates that modifications of the item are necessary to obtain adequate performance, the modification shall be documented and the item shall be modified and retested or otherwise verified to ensure satisfactory performance.
- When tests are being performed on models or mockups, scaling laws shall be established and verified. The results of model test shall be subject to error analysis, where applicable, before its use in the final design work.

3.2.5 Design Change Control

Changes in approved designs, including field changes, shall be justified. They shall be subjected to the same control measures applied to the original design and shall be approved by the same organizations that reviewed and approved the original design document. In the case where the organization originally responsible for approving a particular design is no longer responsible, the Project Office will designate a new responsible organization that has demonstrated competence in the specific design area of interest and has an adequate understanding of the requirements and intent of the original design. Errors and deficiencies in approved designs and in design information documents shall be documented, and action shall be taken to correct them. Where a significant design change is necessary, the design process and verification procedure shall be reviewed and the procedure shall be modified as indicated. Additionally, training for needed changes shall be considered and the changes with the required training shall be communicated to all affected groups or individuals.

3.2.6 Design Interface Control

Design interfaces internal and external to LANL shall be identified and controlled, and the design efforts shall be coordinated. Interface controls include the documented assignment of responsibility and the establishment of procedures for the review, approval, release, distribution, and revision of documents involving design interfaces.

Design information transmitted across interfaces shall be documented and controlled. Transmittals shall identify the status of design information or documents provided and, when

necessary, identify incomplete items that require further evaluation, review, or approval. Where it is necessary to initially transmit design information informally, the design information shall be confirmed promptly by a controlled document.

3.2.7 Design Output Requirements

Completed designs shall be documented and shall relate to design input in sufficient detail to permit design verification. This documentation shall identify assemblies or components that are part of the designed item. When such an assembly or component part is a commercial-grade item and is modified or selected by special inspection and/or testing to requirements that are more restrictive than the supplier's published product description, the component part shall be represented as different from the commercial-grade item, and the difference is defined and documented.

The design document shall show evidence that the required review and approval cycle has been achieved before its release for use in procurement or construction or release to another organization for use in other design activities. As a minimum, the review and approval cycle shall include the participation of the technical and QA elements of both the responsible design organization and the Project Office. The purpose of the QA review is to ensure that the documents are prepared, reviewed, and approved in accordance with documented procedures and QA requirements.

3.2.8 Design Documents as Quality Assurance Records

Design documentation, including design input, analyses, drawings, specifications and approved changes, evidence of design verification, and records confirming interface control, shall be collected, controlled, stored, and maintained as QA records in accordance with LANL records management procedures.

3.3 Software Quality Assurance Requirements

Appendix H of this QAPP describes the software requirements for the LANL YMP and shall be used in conjunction with the following sections.

For a geologic repository, computer software used to support license application shall be controlled to the same level of requirements as software used to perform direct design analysis. Auxiliary software used to support primary data software shall be controlled at a level commensurate with the complexity of that software.

Where commercial auxiliary software is used, all available documentation from the software supplier shall be obtained. It is recognized that source code is generally not available and controls are limited to unique version identification and user-related manuals. Supplemental, detailed requirements for the development, maintenance, and security of computer software are contained in Appendix H.

3.3.1 Computer Software Documentation and Control

Appendix H to this QAPP provides detailed requirements on the content of software documentation used on the YMP. Computer programs developed and/or modified shall be documented in accordance with the applicable elements of NUREG-0856. This requirement may be met in part by existing documentation, if properly referenced and related to NUREG-0856 requirements.

Software QA documentation is a QA record and shall be controlled as per Section 17 of this QAPP.

3.3.2 Software Description

LANL shall prepare a Software QA Plan (SQAP) as described in Appendix H to describe its software design, test, and configuration management system. The SQAP shall be submitted to the Project Office for review and approval.

3.3.2.1 Baseline Elements

Software shall be placed under configuration management as each baseline element is approved. Software baseline elements shall be uniquely identified to ensure positive control of all revisions; the identification of each code version shall be directly related to the associated documentation.

3.3.2.2 Software Changes

Changes in software shall be systematically evaluated, coordinated, and approved to ensure that the impact of a change is carefully assessed before updating the baseline, that required action is documented, and that the information concerning approved changes is transmitted to all affected organizations. Changes in computer software shall be subject to the same level of approval, verification, and validation as the original software.

3.3.2.3 Software Testing

Testing of software, including new or modified software, shall be performed for those inputs and conditions necessary to exercise the software, to identify boundary conditions, and to provide a suitable benchmark or sample problem for installation. The goal of testing is to develop a set of test cases that have a high probability of detecting the errors in order to determine the conditions under which the software will not perform properly.

3.3.2.4 Qualification of Existing Software

Existing software shall be qualified for use. This qualification shall be based on the ability of the software to provide acceptable results for specific applications and compliance with the requirements of this section and Appendix H.2. Software that has not been developed in accordance with this QAPP may be qualified for use, provided that the software is verified and validated, a software baseline is established, and applicable documentation is prepared to support the software.

3.3.2.5 Interface Management

Methods for determining the applicability of requirements and managing interfaces involving software, documentation, configuration management, change, qualification, verification, and validation will be described in the SQAP.

3.3.2.6 Software Configuration Management

The minimum requirements for a configuration management QP shall include a unique identification, including software version numbers, whenever feasible, in the output;

listings of the software; and a brief chronology of the software versions, including descriptions of the changes made between controlled versions of the software.

3.4 Technical Reviews

Technical reviews shall be performed in accordance with a QP that defines the following:

- the criteria for selection of the technical reviewers,
- the procedure for technical reviews, and
- the method of review documentation.

3.5 Peer Reviews

When applicable, LANL shall institute a peer review process to provide adequate confidence in the work being reviewed. A peer review QP shall meet the requirements of NUREG-1297 and Appendix J of this QAPP.

4.0 PROCUREMENT DOCUMENT CONTROL

4.1 Procurement Document Requirements

Documents for procurement of material, equipment, and services used in LANL YMP activities shall include or reference applicable regulatory requirements, design or site investigation bases, and other requirements necessary to ensure quality.

Procurement documents shall contain the following information as appropriate:

- a scope of work description,
- the technical requirements for the work,
- QA Program requirements,
- a right-of-access provision,
- subcontracting requirements (including the subcontractor's pass-through of appropriate QA requirements),
- documentation requirements, and
- nonconformance provisions.

4.1.1 Scope of Work

The procurement documents shall clearly define the scope of the work to be performed by the supplier or subcontractor.

4.1.2 Technical Requirements

The procurement documents shall specify the technical requirements for the work. Where necessary, these requirements shall reference specific drawings, specifications, codes, standards, regulations, procedures, or instructions, including any revisions thereto, that describe the items or services to be furnished. The procurement documents shall identify test, inspection, and acceptance requirements for monitoring and evaluating supplier or contractor performance.

4.1.3 Quality Assurance Program Requirements

For noncommercial-grade procurements, a LANL supplier or subcontractor shall be required to have a documented QA Program that implements all the applicable QA requirements of this document as selected by the requester. Subcontractors' QAPPs and related documents, including changes thereto, shall be reviewed and approved by the requester and QA representative. Upon review, if additional QA elements are required, they shall be specified and incorporated in the subcontractor's QA Program before the initiation of procured activities. The extent of the program required depends upon the type and use of the item or service being procured.

In the development of QA requirements for measuring and other equipment, consideration shall be given to whether proper performance of that equipment can be determined during or after its use (i.e., whether failure or malfunction of the equipment can be detected).

4.1.4 Right of Access

QA Level I and II procurement documents shall provide for access to the suppliers' facilities or their subcontractors' facilities and to their records for inspection or audit by the purchaser and appropriate Project Office personnel. When audits of suppliers or their subcontractors are performed by LANL or other YMP personnel, the LANL procurement organization shall be notified and then coordinate with the requester to arrange access.

4.1.5 Documentation Requirements

Procurement documents shall identify the documentation (reports, manuals, certification, etc.) required from the supplier or their subcontractors and shall specify the time of submittal. QA Level I procurements from LANL in-house suppliers shall be considered internal supplies and are not documented as procurement but shall be appropriately qualified for its intended use. Measuring and test equipment are qualified for the Project through calibration.

4.1.6 Nonconformance

Procurement documents shall prescribe the requirements for reporting and approving the disposition of nonconformances as appropriate to the specific procurement. Section 15 contains more information on nonconformance.

4.2 Review of Procurement Documents

A review of the procurement requests and of changes in procurement specifications shall be made to ensure that documents transmitted to the prospective supplier or contractor include all appropriate provisions to require that items or services meet the specifications.

Before a contract is awarded, personnel who have access to pertinent information and an adequate understanding of the requirements and intent of the procurement documents shall perform and document the review. The review shall be performed by the requester and QA representative, as a minimum. The QA review shall ensure that

- the QA requirements are stated correctly and are inspectable and controllable;
- there are adequate acceptance and rejection criteria; and
- the procurement documents have been properly prepared, reviewed, and approved.

4.3 Procurement Document Changes

Changes in procurement documents shall be subject to the same degree of control used in the preparation of the original documents. Changes made as a result of the bid evaluation or precontract negotiations shall be incorporated in the procurement documents. Before a contract is awarded, a review and evaluation of such changes and their effects will be completed, documented, and approved by the requester.

The review of changes shall include

- that appropriate content is included within the procurement documents;
- that additional or modified design/site investigation criteria is determined, if applicable; and
- that supplier requested changes or exceptions are evaluated for impact on the intent of the original procurement document.

4.4 Distribution of Procurement Documents

Copies of QA Level I procurement documents and changes therein that state the vendor, the scope of work, and the date when work is to start shall be sent to the Project Office QA Department.

5.0 INSTRUCTIONS, PROCEDURES, PLANS, AND DRAWINGS

5.1 General

Activities affecting quality shall be prescribed by, and performed in accordance with, documented instructions, procedures, plans, or drawings written according to QPs. LANL procedures consist of QPs and DPs prepared in accordance with this QAPP. These documents, including drawings, shall be developed by qualified personnel, controlled as required by Sections 6 and 17 of this document and distributed according to QPs. For the production of drawings, the initiating organization shall establish procedures, when directed, for the initiation, review, approval, issue, and change control.

5.2 Criteria

Instructions, procedures, and plans shall specify appropriate quantitative or qualitative criteria for determining satisfactory work performance and QA compliance and identify the QA records to be generated during implementation of the document. The documents shall specify the checkpoints in the work process at which compliance with the criteria shall be determined and verified. Criteria for approval or rejection shall be provided for all inspections of products and for construction and monitoring of methods, and equipment. Means for identifying approved or rejected products or services shall also be provided.

5.3 Reviews

Independent technical reviews of all instructions, procedures, plans, and drawings shall be performed by the originating organization in accordance with QPs before their implementation. The technical adequacy of procedures for conducting scientific investigations shall be reviewed and approved by qualified persons other than those who prepared the procedures. Before instructions, procedures, and plans are implemented at LANL, they shall be reviewed by the QA organization, in accordance with QPs, to ensure that they meet all requirements of this QAPP. Reviews of instructions, plans, procedures, and drawings should consider if the activities described therein (1) are repeatable, (2) will affect waste isolation capabilities, and/or (3) will interfere with other site characterization activities.

5.4 Distribution

The QAPP and all procedures, plans, instructions and drawings shall be maintained and provided to the PQM as part of the controlled distribution for all QA Level I and II activities documents.

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6.0 DOCUMENT CONTROL

6.1 Document Preparation, Review, Approval, and Issue

The preparation, review, approval, and issue of documents (such as instructions, administrative procedures, plans, and drawings, including changes therein) shall be controlled to ensure that correct documents are available for use at the proper location. Document control shall be implemented through procedures and shall be applied to documents that contain or specify quality requirements and documents that prescribe activities affecting quality.

The document control system shall be prescribed in a QP, and the QA organization shall provide review, resolution of comments, and approval of quality-related aspects of the documents.

6.2 Implementation of Document Control

Documents shall be controlled according to a QP that

- identifies documents to be controlled;
- assigns responsibility for preparing, reviewing, approving, and issuing documents;
- defines instructions for reviewing documents for adequacy, completeness, correctness, and inclusion of appropriate quality requirements before approval and issue;
- prescribes a method for removing or marking obsolete or superseded documents, in a timely manner, to prevent inadvertent use;
- prescribes a method for ensuring that the correct and applicable documents are available at the location where they are to be used;
- requires a master list or equivalent to identify the correct and updated revisions of documents; and
- delineates interface documents.

6.3 Changes in Documents

Changes in documents shall be reviewed and approved by the same organizations that originally reviewed and approved the document, unless other organizations are specifically designated by the organization responsible for the document. The reviewing organizations shall have access to pertinent background data or information upon which to base their approval. Reviewers shall specifically consider whether changes to the process are not repeatable, have the potential to affect waste isolation capability of the site, or interfere with other site characterization activities.

Minor changes in documents limited to inconsequential editorial corrections do not require the same review and approval as the original documents. Editorial corrections will be verified that they do not substantially change the document before the documents are issued.

6.4 Distribution of Documents

The document control system shall ensure that documents requiring verification are not released before verification or, if they must be released before verification, that they are uniquely identified and controlled in accordance with Subsection 6.2 above. A master list or equivalent used to identify the correct, current, and updated versions of documents shall be submitted to the PQM by the Records Coordinator. LANL shall issue to the PQM controlled copies of all LANL implementing procedures, plans, instructions, and the QAPP used for QA Level I and II activities. In addition, procedures, plans, and instructions for QA Level I and II activities shall be accessible for review in the area where the activity is performed.

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7.0 CONTROL OF PURCHASED ITEMS AND SERVICES

7.1 General Requirements

Procurement shall be conducted in accordance with LANL QPs. Purchased material, equipment, and services shall conform to the requirements of procurement documents. These methods include source evaluation and selection, the examination of objective evidence of quality, inspection at the contractor or subcontractor source, audit, and examination of products upon delivery as specified in the procurement documents. Organizational responsibilities shall be stated in a QP. This documentary evidence shall be handled as specified in Section 17. Specific requirements for the purchase of items and services are listed below.

7.1.1 Procurement Planning

Procurement activities shall be planned and documented to ensure a systematic approach to procurement. The QA organization shall participate in the qualification of supplier, verification of supplier activities, and monitoring receipt inspection. Planning shall be accomplished as early as practicable and no later than the start of YMP procurement activities. Planning shall determine what is done, who does it, how it is done, and when it is to be accomplished.

Planning results in the documented identification of procurement methods, the sequence of actions and milestones that indicate the completion of these activities, and the preparation of applicable procedures before the initiation of each individual activity listed below. Planning considers the following:

- preparation, review, and change control of procurement documents;
- selection of procurement suppliers;
- control of supplier performance;
- verification through survey, inspection, or audit of activities, including specification of hold-and-witness points;
- control of nonconformances;
- execution of corrective action;
- acceptance of an item or service; and
- preparation of QA records.

7.1.2 Evaluation and Selection of Suppliers

Before a contract is awarded, suppliers shall be selected based on an evaluation of their ability to provide items or services in accordance with the requirements of the procurement documents.

Criteria for evaluation and selection of procurement sources, and the results thereof, shall be documented and shall include one or more of the following items:

- an evaluation of the suppliers' histories, including current capabilities, of providing identical or similar products that perform satisfactorily in actual use;
- an evaluation of the suppliers' current QA records supported by documented qualitative and quantitative information that can be objectively evaluated; and
- an evaluation of the suppliers' technical and quality capabilities as determined by a direct evaluation of their facilities and personnel and the implementation of their QA Program.

7.1.3 Bid Evaluation

Bid evaluation shall determine the extent of conformance to the procurement documents. The evaluation, by the designated organizations, shall consider the following, as applicable to the type of procurement:

- technical considerations,
- QA requirements,
- personnel,
- production capabilities,
- past performance,
- alternates, and
- exceptions.

Before the contract is awarded, the purchaser shall resolve unacceptable QA conditions identified during the bid evaluation.

7.1.4 Interface Measures

The interface between the supplier and the purchaser includes the following:

- review of supplier documents that are generated or processed during activities fulfilling procurement document requirements,
- supplier identification of planning techniques and processes, when applicable;
- methods of exchanging document information; and
- a method of identifying and processing necessary change information. (Measures to control changes in procurement documents shall be established, implemented, and documented in accordance with the requirements of Subsection 4.3 of this QAPP.)

7.1.5 Evaluation of Supplier Performance

7.1.5.1 Verification Measures

The purchaser of items and services shall establish measures to verify the supplier's performance and to establish the extent of source survey and inspection activities. The extent of verification activities, including planning, is a function of the relative importance, complexity, and quantity of the item or services procured and the supplier's quality performance. Verification activities shall be accomplished by qualified personnel assigned to check, inspect, audit, or witness the supplier's activities (i.e., a preaward survey).

These verification activities shall be conducted as early as practicable. However, LANL's verification activities do not relieve the suppliers of their responsibilities for verification of quality achievement.

When using another participating organization, LANL will request the PQM to conduct a survey to determine that the item or activity is being produced or performed in accordance with LANL requirements.

7.1.5.2 Record of Evaluation and Verification

Activities shall be performed to verify conformance with requirements of procurement documents and their results shall be recorded. Source surveys and inspections, audits,

receiving inspections, nonconformances, dispositions, waivers, and corrective actions shall be documented. These completed documents shall be considered QA records and shall be controlled in accordance with Section 17 of this QAPP. This documentation is evaluated to determine the supplier's QA Program effectiveness.

7.1.6 Control of Documents Generated by Suppliers

Documents generated by suppliers shall be submitted in accordance with requirements of the procurement documents and shall be handled, approved, and controlled according to LANL QPs for document control. The documents shall be evaluated against the criteria for procurement acceptance.

7.1.7 Acceptance of Item or Service

Methods shall be established for the acceptance of items or services being furnished by the supplier. The supplier or contractor shall verify that an item or service complies with the procurement requirements before its submission for acceptance. Documentation of acceptance shall be considered a QA record and maintained in accordance with Section 17 of this QAPP.

Acceptance of services performed shall require documentation of surveys and audits, a technical review of data generated, or other objective evidence of satisfactory performance.

Methods of acceptance for items include

- a supplier certificate of conformance,
- a source verification,
- a receiving inspection,
- a postinstallation test at the facility site, or
- a combination of the above.

7.1.7.1 Certificate of Conformance

The following minimum criteria apply to a certificate of conformance.

- The certificate shall identify the purchased material or equipment.
- The certificate shall identify the specific procurement requirements met by the purchased material or equipment, including codes, standards, or other specifications. Identification shall be accomplished by including a list of the specific requirements or by providing, at the point of receipt, copies of the purchase order, the procurement specifications or drawings, and a suitable certificate. The procurement requirements identified shall include any approved changes, waivers, or deviations applicable to the subject material or equipment.
- The certificate shall identify any procurement requirements that have not been met, shall explain the nonconformance, and shall propose a means of resolution.
- The certificate shall be validated by a person responsible for this QA function described in the supplier's QA Program.
- The certificate system, including the procedures followed in completing a certificate and the administrative procedures for the review and approval of the certificates, shall be described in the supplier's QA Program.
- The validity of supplier certificates and the effectiveness of the certification system shall be verified during the performance of audits of the supplier, or independent inspection, or test of the items. Such verification shall be conducted at intervals commensurate with the supplier's past quality performance.

7.1.7.2 Source Verification

If source verification is performed, it shall be done at intervals that are consistent with the importance and complexity of the item or service. Source verification shall be implemented to monitor, witness, or observe activities. Verification shall be implemented in accordance with plans to perform inspections, examinations, or tests at predetermined points. Once the source verification is accepted, LANL (the receiving destination of the item) and the supplier shall be furnished with documented evidence of acceptance of the item.

7.1.7.3 Receiving Inspection

Purchased items shall be inspected as necessary to verify their conformance to specified requirements. Inspections shall take into account source verification, audit documentation, and the demonstrated quality performance of the supplier. Receiving inspection shall be performed in accordance with LANL QPs. Supplier documentation that material or equipment conform to procurement requirements will be available for review at receipt inspection and/or prior to installation or use. Receiving inspections shall be based on objective evidence criteria—such as physical, dimensional, damage—or other measurable characteristics. Technical personnel, who are familiar with the objectives of the research and have been indoctrinated to the applicable codes, standards, and QA requirements shall perform the receipt inspections. These technical personnel shall have the experience and training commensurate with the scope, complexity, or special nature of receipt inspection.

7.1.7.4 Postinstallation Testing

Postinstallation testing requirements and acceptance documentation shall be established between LANL and the supplier in the procurement document.

7.1.8 Procurement of Services

In cases involving procurement of services, including third-party inspections, engineering, analysis, consulting, installation, repair, overhaul, or maintenance work, acceptance shall be made according to the following methods:

- technical verification of data produced;
- a survey and/or audit of the activity; or
- a review of evidence, such as certifications and stress reports, for conformance to the requirements for procurement documents.

7.1.9 Control of Supplier-Issued Nonconformances

Requirements involving the control of supplier-issued nonconformances for the item or service being procured shall be stipulated in the purchasing document.

The nonconformance report (NCR) issued by the supplier shall contain the following minimal information:

- the technical or material requirement violated, with reference to the procurement document;
- a consideration of whether the nonconformance can be corrected by continuation of the original process or rework;

- an evaluation of nonconforming items;
- a submittal of a nonconformance notice to the requester;
- the process correction proposed, when applicable;
- the recommended disposition (i.e., use-as-is, repair, rework, or reject); and
- technical justification for the disposition.

The submittal of a nonconformance notice shall include a disposition recommendation (e.g., use-as-is or repair) and technical justification. Supplier dispositions are approved and implementation is verified by the requester in accordance with the LANL QP. Supplier nonconformance reports shall be processed and reviewed by the requestor according to a LANL QP and maintained as QA records.

Disposition of nonconformances by the requester includes

- an evaluation and approval of the supplier's corrective action (if applicable),
- maintenance of records of nonconformance, and
- verification of the corrective actions.

7.2 Commercial-Grade Items

If a design or scientific investigation requires commercial-grade items, then the following requirements and the requirements of Section 4 of this QAPP shall be used to accept the items.

7.2.1 Identification of Commercial-Grade Items

Where the commercial-grade item is to be used, it shall be properly identified in approved design or design activity documents and will meet applicable requirements. An alternate commercial-grade item may be supplied if the cognizant organization provides verification that the alternate commercial-grade item will perform the intended function and will meet the requirements applicable to both the replaced item and its application.

7.2.2 Source Evaluation and Selection

Source evaluation and selection shall be in accordance with Subsection 7.1.2 when the requestor determines that such activity is necessary based on the complexity of the item and its importance to safety.

7.2.3 Purchase Order

Commercial-grade items shall be identified in the purchase order by the manufacturer's published product description (e.g., the catalog number).

7.2.4 Receipt of Commercial-Grade Items

Receipt of a commercial-grade item shall determine that

- damage was not sustained during shipment;
- the item received was the item ordered;
- the required receipt inspection or testing is accomplished in accordance with written procedures to ensure conformance with the manufacturer's published requirements, and, if applicable, acceptance of the item may be accomplished by way of a calibration program in accordance with Section 12 of this QAPP and the associated procedure; and
- documentation, as applicable to the item, has been received and accepted.

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8.0 IDENTIFICATION AND CONTROL OF SAMPLES AND DATA

8.1 Identification and Control of Samples

These requirements shall apply to samples used in or resulting from scientific investigations.

Samples shall be identified and controlled according to LANL DPs. Such procedures shall define the responsibilities (including interface between organizations) for the collection, identification, handling, storage, and transportation of samples and for the generation of records regarding such.

Samples shall be collected according to LANL DPs to ensure that collection methods produce the intended sample. Sample-handling methods shall be documented and shall be used to ensure that all samples meet the technical objectives dictated by the scientific investigation for which the samples are collected.

Transportation methods shall be described in, and effected by, LANL DPs prescribing appropriate containers, methods of handling, and any other environmental or safety considerations for the sample. Where multiple organizations are involved, appropriate procedures shall define responsibilities and documentation methods to be used.

Controls shall be implemented to ensure that sample identification is verified and maintained when samples are handled, transported, or transferred from one organization's responsibility to another for use or analysis.

Samples shall be identified by placing the identification directly on the sample, on its container, or on records traceable thereto. When it is impractical to place the identification on the samples, an alternative method shall be implemented to ensure that samples are not mixed with like samples and that the correct identification of samples is verified and documented before the samples are released for use.

Physical identification shall be used to the maximum extent possible. Where physical identification cannot be placed on the sample, appropriate alternative identification methods shall be used whereby identification of samples can be traced to the appropriate documentation, such as drawings, specifications, drilling logs, test records, inspection documents, and NCRs.

Samples shall be stored and maintained in predetermined physical conditions commensurate with their intended purpose. Samples intended for long-term storage shall receive treatment to ensure that they do not degrade during storage. "Long term" is defined by the scientific investigation planning document for each sample collection case.

Measures shall be taken to maintain sample identification consistent with the planned duration and conditions of storage. Consideration shall be given to the maximum storage life expected of the sample. Physical segregation of samples to preclude mixing with like samples shall be used to the maximum degree practical.

LANL procedures shall be based upon the YMP AP describing the ultimate storage of all types of samples, including liquids, gases, and solids. The procedures shall, as a minimum, address the transportation, handling, storage, and retrievability of samples and the generation and retention of records. All records generated as a result of the testing of the samples shall be handled in accordance with Section 17 of this document.

.2 Identification and Control of Data

The requirements included here shall apply to data generated by a LANL YMP scientific investigation. Data generated by a scientific investigation shall be identified to assist in the determination of their correct use. Identification of such data shall be provided in all documents and information systems in which such data appear. The identification of data shall include a reference to the origin of the data (task, test, experiment, report, publication, etc.) and an indication of the QA level assigned to the activity that produced the data.
Control measures shall be implemented to ensure that data are properly identified. These measures shall include verification of the identification of data before their release for use.

Where data are the results of the efforts of more than one organization, QPs describing the organizational responsibilities for those data shall be developed and implemented. The documentation resulting from the scientific investigation involving more than one organization shall be annotated to show which organization produced what portion of the data.

9.0 CONTROL OF PROCESSES

The requirements for process control shall apply to engineered items and scientific investigations; the requirements for special process control apply to engineered items only that are not a part of the LANL scope-of-work. All processes shall be controlled by instructions, procedures, plans, drawings, checklists, travelers, or other appropriate means to ensure that process parameters are controlled and that specific environmental conditions are maintained.

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10.0 INSPECTION

The requirements of this section of the Project Office QAP apply to engineered items and do not apply to scientific investigation activities.

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11.0 TESTING

LANL does not currently conduct any activities to which testing requirements apply.

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12.0 CONTROL OF MEASURING AND TEST EQUIPMENT

12.1 Scope of Control Program

Tools, gauges, instruments, fixtures, reference or transfer standards, nondestructive test equipment and other measuring and test equipment used in activities affecting quality shall be controlled. They shall be calibrated and adjusted at specified periods to maintain measurement accuracy within specified limits. The scope and methodology of the control program includes all equipment or systems used to calibrate, measure, gauge, test or inspect, either to control or to acquire data, to verify conformance to a specified requirement, or to establish characteristics or values not previously known. Calibration and control measures are not required for rulers, tape measures, levels, and other such devices if normal commercial equipment provides adequate accuracy. Procedures shall be established for calibration (technique and frequency), maintenance, and control of measuring and test equipment used for measurement, inspection, and monitoring. The review and documented concurrence of these functions shall be identified in the procedures.

12.2 Description of Responsibilities

All organizations using and calibrating measuring and test equipment shall establish and implement a calibration program through DPs. The QAPL shall be responsible for evaluating each program and for ensuring that it is effective and complies with the QP.

12.3 Program Requirements

Calibration programs shall include specifications for selection, calibration, capability, handling, and storage of measuring and test equipment.

12.3.1 Selection

Selection of measuring and test equipment shall be controlled to ensure that such equipment is of proper type, range, accuracy, and tolerance to accomplish the intended function. The type, range, accuracy, and tolerance of a measuring device shall be specified in DPs, logbooks, instruction books, or other appropriate places. Each device shall have a unique identification number. This number shall be recorded on the data sheet, log, etc., along with the measurement taken, to ensure traceability.

12.3.2 Calibration

Measuring and test equipment covered by these requirements shall be calibrated against certified equipment having known valid relationships to the National Bureau of Standards (NBS) or other nationally recognized standards and shall be calibrated, adjusted, and maintained at prescribed intervals. If no nationally recognized standards exist, the basis for calibration shall be specified and documented in a DP, QP, logbooks, or notebooks. Calibrating standards shall have equal or greater accuracy than that required of the equipment being calibrated. Calibrating standards with the same accuracy may be used, provided they can be shown to be adequate for the requirements and that the basis of acceptance is documented and approved by the PI.

12.3.3 Capability

The method and interval of calibration for each item shall be defined, based on the type of equipment, stability characteristics, required accuracy, precision, intended use, degree of usage, and other conditions that affect measurement control. Measuring and test equipment shall be

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13.0 HANDLING, SHIPPING, AND STORAGE

13.1 General

Work and inspection instructions, drawings, specifications, shipment instructions, or other procedures, shall be established as necessary to control the packaging, handling, storage, shipping, cleaning, and preservation of material and equipment to prevent damage, loss, or deterioration. Such instructions shall specify the following:

- special equipment and protective environments,
- specific procedures,
- inspection and testing of any special tools and equipment,
- training of special equipment operators, and
- marking and labeling.

13.2 Special Equipment and Protective Environments

When required for particular items, special equipment (e.g., containers, shock absorbers, and accelerometers) and special protective environments (e.g., an inert gas atmosphere, specific moisture content levels, and temperature levels) shall be specified in the pertinent instructions provided by the responsible organization, and their existence shall be verified by the QA organization.

13.3 Specific Procedures

When required for critical, sensitive, perishable, or exceptionally expensive articles, DPs shall be written for handling, storage, packaging, shipping, and preservation. DPs shall be subject to LANL QAPL approval.

13.4 Inspection and Testing of Special Tools and Equipment

Any special-handling tools and equipment shall be used and controlled as necessary to ensure safe and adequate handling. Special-handling tools and equipment shall be inspected and tested in accordance with approved procedures and at specified time intervals to verify that the tools and equipment are adequately maintained.

13.5 Training of Special Equipment Operators

Operators of lifting and special-handling equipment shall be experienced or shall be trained to use the equipment. Verification and documentation of this training shall be maintained as QA records in accordance with LANL QPs.

13.6 Marking and Labeling

Marking and labeling instructions for packaging, shipment, handling, and storage of items shall be specified in LANL DPs to adequately identify, maintain, and preserve the item. Marking requirements for special environments or special controls shall also be specified in LANL DPs.

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14.0 INSPECTION, TEST, AND OPERATING STATUS OF ENGINEERED ITEMS

The Project Office QAP requirements of inspection, test, and operating status apply to engineered items and do not apply to scientific investigations.

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15.0 CONTROL OF NONCONFORMANCES

15.1 General

Measures shall be established to control nonconforming items and activities and to prevent their inadvertent installation, use, or performance. These measures shall include the use of documented procedures for identification, documentation, evaluation, segregation (when practical), disposition, and notification to affected organizations. All LANL YMP personnel shall be responsible for reporting nonconformances in accordance with their approved procedures for nonconformance control. These procedures shall be consistent with the requirements discussed below.

15.2 Identification

Identification of nonconforming items shall be made by marking, tagging, or other methods that do not adversely affect the end use of the item. The identification shall be legible and easily recognizable and shall contain the NCR number. The method for tracking the NCR status and QA organizational responsibilities shall be clearly stated in a QP. Internal and external interfaces shall be clearly defined.

15.3 Nonconformance Control Log

Nonconformances shall be tracked in a nonconformance control log that contains the following information:

- the NCR number (a sequential number preceded by "LANL"),
- a brief description of the nonconforming condition,
- identification of the person or organization responsible for determining and carrying out the nonconformance disposition, and
- the status of each NCR (open or closed).

15.4 Segregation

When practical, nonconforming items shall be segregated by placing them in a clearly identified and designated holding area until their dispositions are accomplished. When segregation is impractical or impossible because of physical conditions such as size, weight, or access limitations, other precautions shall be employed to preclude inadvertent use of nonconforming items. Tags shall be permitted if they are securely attached to the items, or the items shall be placed within a unique storage area if a place is so designated. Segregation is not applicable to nonconforming activities.

15.5 Disposition

Processing, delivery, installation, use, or performance of a nonconformance shall be controlled pending an evaluation and approved disposition by authorized personnel. Recommended dispositions of nonconforming items shall be proposed, reviewed, and approved in accordance with documented procedures. Nonconformance documentation shall be distributed to all affected organizations upon issue and closure.

15.5.1 Responsibility and Authority

The organization using or producing the nonconformance shall be responsible for its evaluation, disposition, and close-out. Those persons who are assigned signature approval of the disposition shall be identified in the QP. The QA responsibilities shall include approval of the disposition and verifying closeout of nonconformances.

15.5.2 Personnel

Persons selected to evaluate nonconformances to determine a disposition shall have demonstrated competence in the specific area under evaluation and an adequate understanding of the requirements and shall have access to pertinent background information.

15.5.3 Disposition of the NCR

Persons responsible for dispositioning the NCR shall ensure that the following requirements are met.

- Nonconformance documentation shall adequately identify and describe the nonconformance.
- Appropriate justification for the disposition shall be documented. In the case of use-as-is or repair dispositions of the item, technical justification shall be required. Such dispositions shall require the approval of the appropriate YMP Branch Chief and the PQM prior to implementation. The records of as-built items, if such records are required, shall reflect the accepted deviation.
- The NCR shall refer to any approved design documents, procedures, plans, work orders, etc., to be used for the correction of the nonconforming condition.
- The technical details for correction of the nonconforming condition shall be adequate for the recommended disposition.
- If continuance is requested, justification for the continuance will be documented and then approved by the TPO, QAPL, PQM, and YMP Branch Chief.
- The disposition shall comply with existing design documents, test plans or procedures, reports, and regulatory requirements.
- If a change is appropriate to reflect the as-built condition of an item, then the disposition shall address the action needed to change the existing design documents, test plans or procedures, reports, etc. Any documents changed shall have a cross reference on the NCR.
- The disposition shall identify and document the correction as repair, rework, use-as-is, or reject/scrap.
- The disposition shall identify the personnel responsible for implementing the disposition.
- The disposition shall describe the cause of the nonconforming condition.
- The disposition shall document action needed to preclude recurrence of the nonconforming condition.

15.5.4 Project Office Notification

Copies of NCRs shall be sent to the PQM upon issuance and closure.

15.5.5 Corrective Action

Action taken to correct the nonconformance shall be verified and documented. Repaired or reworked items shall be re-examined in accordance with applicable procedures and with the original acceptance criteria, unless the disposition has established alternate acceptance criteria.

15.6 Conditional Release

Work on a nonconformance shall be stopped until the NCR disposition is complete. If only a specific portion of an item or activity is in nonconformance, then that specific portion shall be identified and work may proceed on the remaining areas or subtasks. However, work on a nonconformance may continue (conditional release) before implementation of the disposition when approved by the QAPL,

TPO, PQM, and YMP Branch Chief. Requests for conditional releases on nonconformance shall document that the following conditions are met:

- the nonconformance can be removed or corrected at a later date without damage to, or contamination of, the associated permanent facility equipment or structures;
- if the nonconformance is related to an item, the item shall remain accessible for inspection;
- the nonconformance shall have been evaluated and limitations for use of the equipment or system established; and
- traceability and identification of the nonconformance shall be maintained.

15.7 Nonconformances and Trending

The NCRs shall be periodically analyzed by the QA organization to establish quality trends and to help identify root causes of nonconformances. The results shall be reported to the TPO and QAPL for review and assessment. When repetitive or recurring nonconforming conditions are identified (as a trend), an evaluation shall be made as to whether further programmatic corrective action (Section 16) is warranted to preclude repetition. This corrective action shall be beyond the scope of the action taken for the disposition of the existing NCRs and shall be processed in accordance with LANL corrective action procedures.

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16.0 CORRECTIVE ACTION

16.1 General

The corrective action system shall ensure that repetitive nonconformances and/or conditions adverse to quality, including supplier nonconforming activities and services, shall be identified promptly, documented on corrective action reports, and corrected as soon as practical.

16.2 Significant Adverse Conditions

For significant conditions adverse to quality, the identification, cause, and corrective action taken to preclude recurrence shall be documented and reported to immediate management and upper levels of management for review and assessment. Assessment may result in a stop work order. A significant condition adverse to quality is one that, if not corrected, could have a serious effect on safety or operability. Significant conditions shall include, but shall not be limited to, breakdowns in the QA Program and repetitive nonconformances. Upon discovering or receiving notification that a significant condition adverse to quality exists, LANL shall ensure that

- immediate action has been taken to remedy the specific condition(s);
- any root cause has been determined;
- controls are reviewed, implemented, monitored, and revised, if necessary; and
- affected managers at all levels are notified of the adverse condition(s) and of additional training, if necessary, to improve conditions or to avoid similar occurrences.

16.3 QA Follow-Up Action

The QA organization shall document concurrence with the adequacy of proposed corrective actions to ensure that QA requirements are met. Follow-up action shall be taken by the QA organization to verify proper implementation of the corrective action, to document its acceptance, and to close-out the action. The organization responsible for implementing the corrective action shall ensure that the corrective action is completed in a timely manner. Failure to properly complete corrective action steps in a timely manner may result in a stop work order.

16.4 Corrective Action Reports

The QA organization shall periodically analyze corrective action reports to establish quality trends. The results shall be reported to the TPO and QAPL for review and assessment. Copies of corrective action reports shall be sent to the PQM by the QAPL upon issue and closure.

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17.0 RECORDS

17.1 General

Records that furnish evidence of quality shall be specified, prepared, and maintained in accordance with QPs that meet the requirements of this section. Records management QPs shall be issued at the earliest practical time consistent with the schedule and work activities. The term "records" used in this section means QA records.

17.2 Management, Control, and Preservation of Records

QPs shall be consistent with the Project Office AP-1.7Q, YMP QA Records Management. Responsibilities and methods for record transmittal, distribution, retention, maintenance, retrievability, and status of QA records shall be specified in the QPs.

QPs shall define the implementation of the record system and shall identify measures for the prevention of delays between record completion and storage at the LANL Records Processing Center (RPC) and for the preservation and safekeeping of the records.

For purposes of record retention, all LANL YMP records, including superseded records, shall be classified as lifetime records and shall be retained for the life of the LANL YMP.

17.3 Minimum Records

Sufficient records shall be specified, prepared, and maintained to furnish evidence of the activities that affected quality. All operating logs and the results of reviews, receipt inspections, audits, monitoring of work performance, materials analysis, qualifications of personnel, and procedures shall be maintained as QA records. Final reports shall contain a listing, by unique number, that enables prompt retrieval of all documents used to compile or evaluate the reports. This listing shall include all referenced documents, peer review or other review documents, computer codes, data sheets, procedures, and plans. All documents referenced by final reports, except references readily available to the public, shall be retrievable from the LANL RPC. A list of typical QA records is contained in Appendix E.

17.4 Generation of Records

A document is not considered to be a QA record until it satisfies the definition of a QA record (Appendix A). Records to be generated, supplied, or maintained by or for LANL shall be specified in design documents, procurement documents, implementing procedures, or other documents. Records shall be legible, identifiable, accurate, complete, reproducible on microfilm and other media, and appropriate to the work accomplished. A completed record is defined as a record that will either receive no more entries or whose revision would normally consist of the reissue of the record and that is signed and dated by the originator and, as applicable, by personnel authorized to approve the record. Records shall be completed in accordance with LANL QPs and DPs.

17.5 Validation and Authentication of Records

Records shall be considered valid only if stamped, initialed or signed, and dated by authorized persons or otherwise authenticated in accordance with QPs. Validated records may be originals or reproduced copies.

Record authentication may be a statement by the responsible individual or organization. Handwritten signatures are not required if the record is clearly identified as a statement by the reporting individual

or organization. LANL shall maintain a list that contains the signature and initials of the persons authorized to authenticate records.

17.6 Receipt of Records

Each LANL organization that is responsible for the receipt of records shall designate a person to be responsible for receiving the records. The designee shall be responsible for organizing and implementing a system for receipt control of records for dual storage. The receipt control system shall be structured to permit a current and accurate assessment of the status of records during the receiving process. The receipt control system shall include the following:

- a method for designating the required records,
- a method for identifying the records received,
- a method for acknowledging receipt, and
- procedures for receipt and inspection of incoming records.

LANL organizations responsible for receiving records shall provide protection from damage, deterioration, or loss during the time that the records are in their possession. Each LANL group shall process its records and transfer them to the LANL RPC for further processing and transfer to the Project Office without unnecessary delays.

17.7 Records Identification

The YMP-approved indexing system shall identify the connection between the record and the item or activity to which it applies. Records shall be identified by a unique number or other designation that is directly traceable to controlling program information (e.g., project, contract number, task number, preparing organization, author, date, title, and subject). This identification number or other designation shall not be repeated anywhere in the YMP. The indexing system shall include the location of the record within the records system.

17.8 Storage of Records

Records shall be controlled from the time they are completed until the time they are stored in a permanent storage facility. Temporary storage, preservation, safekeeping, and retrievability of completed records shall be done in accordance with a QP describing the permanent storage of records. The QP shall include the following:

- a description of the storage facility,
- the filing system to be used,
- the method for verifying that the records received are legible and are in agreement with the transmittal document,
- the method of verifying that the records are those designated,
- the rules governing access to and control of the files including retrieval times,
- the method for maintaining control of and accountability for records removed from the storage facility, and
- a method for filing supplemental information.

17.8.1 Responsibilities

The RPC shall be responsible for ensuring that the requirements of QPs for the storage of records are met.

17.8.2 Storage Facilities

Methods for the permanent and temporary storage of records and documents shall be stated in QPs. Records and documents shall be stored in dual facilities constructed and maintained in a manner that minimizes the risk of damage or destruction from natural disasters, such as winds, floods, or fires; environmental conditions, such as high and low temperatures and humidity; infestation of insects or rodents; or mold. The dual facilities shall be predetermined locations sufficiently remote from each other to reduce the chance of simultaneous exposure to a hazard.

17.8.3 Preservation

Records shall be stored in a manner approved by the QAPL. Deterioration of the records shall be precluded by the following.

- Provisions shall be made in the storage arrangement to prevent damage from moisture, temperature, and pressure.
- Records shall be firmly attached in binders or placed in folders or envelopes for storage in steel file cabinets or shall be placed in containers and stored on shelves.
- Special-processed records (radiographs, photographs, negatives, microfilm, magnetic material, etc.) shall be protected from damage caused by excessive light, stacking, electromagnetic fields, temperatures, and humidity.

17.8.4 Safekeeping

The QP shall include safekeeping measures to preclude the entry of unauthorized personnel into the storage area. These measures shall guard against larceny and vandalism.

17.8.5 Replacement, Restoration, or Substitution

Lost or damaged records shall be replaced, restored, or substituted within ninety days of the discovery of the loss or the determination that the damaged record is incomplete or illegible.

17.9 Corrected Information in Records

Records shall be corrected in accordance with LANL QPs that stipulate appropriate review or approval by the originating organization. The correction shall include the date and the identification of the person authorized to issue such correction and shall not obliterate the corrected data.

17.10 Access to QA Records

A list shall be maintained that designates those personnel who have access to the QA record files. Records maintained by LANL at LANL or at any other location (on an interim or other basis) shall be accessible to the Project Office or its designated alternate.

17.11 Transfer of QA Records

The RPC shall review each group's records turnover and shall acknowledge receipt of, inventory, and transfer the records to the Project Office.

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18.0 AUDITS

18.1 General Requirements

All LANL YMP activities are subject to scheduled and planned internal and external audits to ensure that procedures and activities comply with the overall QA Program and to determine the program's effectiveness. The audits shall be performed using check lists in accordance with QPs. Qualified personnel who do not have direct responsibility for performing the activities being audited shall conduct the audits. Audit results, including deficiencies, nonconformances, and potential quality problems, shall be documented and monitored, reviewed by the QAPL, reported to the TPO, and monitored until verification of effective corrective action is made. On the form supplied by the audit organization, the audited organization shall describe the corrective action to be taken to address findings and shall submit the completed form to the QAPL and the audited organization's own management. The audit organization shall track audit findings to ensure that all findings are properly closed and to identify quality trends.

Audits shall be performed by the QA support (QAS) and shall include follow-up action, verification of corrective action, or reaudit of specific areas.

18.2 Audits

LANL shall conduct internal and external audits of activities under its direct control and shall not conduct audits of other participating organizations. These audits shall be scheduled, planned, conducted, and reported as described below and in accordance with QPs.

18.2.1 Scheduling

Internal and external QA audits shall be scheduled annually (date, activity, and requirements) to provide complete coverage of QA Program activities. Audits shall be scheduled at a frequency commensurate with the status and importance of the activity and initiated early enough in the activity to ensure effective QA. The audit schedule shall be prepared annually and evaluated periodically and revised as necessary to ensure that coverage is maintained current. Revisions of the audit schedule shall be documented. LANL shall perform or arrange for annual evaluations of suppliers. This evaluation shall be documented and shall take into account, where applicable, (1) review of suppliers' furnished documents and records such as certificates of conformance, nonconformance notices, and corrective actions; (2) results of previous source verifications, audits, and receiving inspections; (3) operating experience of identical or similar products furnished by the same supplier; and (4) results of audits from other sources, e.g., customer, American Society of Mechanical Engineers, or NRC audits. Regularly scheduled audits shall be supplemented by additional audits of specific subjects when necessary to provide adequate coverage. The audit schedule, including dates and any revisions thereof, shall be sent to the PQM. The audit schedule shall identify the date of the audit, the activities to be audited, and the requirements to which the activities will be audited.

18.2.2 Internal Audits

All applicable elements of LANL's internal QA Program shall be audited at least annually or once during the life of the activity, whichever is shorter. The scope of the audit is established by considering the results of any previous audits; the nature and frequency of identified deficiencies; and any significant changes in personnel, organization, or the QA Program.

18.2.3 External Audits

Applicable elements of an external organization's QA Program shall be audited at least annually or once during the life of the activity, whichever is the shorter period. Exception: If the activity is less than four months in duration, an audit is not required unless it is necessary because of the complexity or importance of the activity being performed. The justification for not performing audits of vendors whose activities are less than four months in duration shall be documented, approved by the QAPL, and sent to the PQM.

If more than one purchaser buys from a single supplier, a purchaser may either perform or arrange for an audit of the supplier on behalf of itself and other purchasers to reduce the number of external audits of the supplier. The scope of this audit shall satisfy the needs of all of the purchasers, and the audit report shall be distributed to all the purchasers for whom the audit was conducted. Nevertheless, each of the purchasers relying on the results of an audit performed on behalf of several purchasers remains individually responsible for the adequacy of the audit.

18.2.4 Audit Plan

An audit plan shall be developed and documented for each audit. This plan identifies the audit scope, audit requirements, audit personnel, activities to be audited, organizations to be notified, applicable documents, schedule, and checklists.

18.2.5 Audit Personnel

Auditors shall be independent of any direct responsibility for the performance of the activities that they are to audit. If the audit is internal, the personnel who have direct responsibility for performing the activities to be audited shall not be involved in the selection of the audit team. Auditors shall have sufficient authority and organizational freedom to make the audit process meaningful and effective. Appendix F defines the requirements for the qualification of QA auditors.

An audit team shall be identified before the beginning of each audit. This team shall contain one or more auditors, one of whom is qualified as a lead auditor, to organize and direct the audit, to coordinate the preparation and issue of the audit report, and to evaluate the responses. The audit team leader identifies technical specialists (if they are necessary) and includes their names in the audit plan. The technical specialists shall have appropriate technical expertise or experience in the work being audited and shall be independent from the work performed. Multidisciplinary teams shall be used when more than a single technical area is to be audited. The audit team leader shall ensure that the audit team is prepared before the audit begins.

18.2.6 Performance

Audits shall be performed using checklists as early in the life of the activity as practicable and shall be continued at intervals consistent with the schedule for accomplishing the activity. The elements selected for an audit shall be evaluated against specified requirements, including a review of any corrective actions taken on deficiencies identified during previous audits in the area being audited. Objective evidence shall be evaluated to determine whether the selected elements are effective and are being implemented properly. The audit results shall be documented by auditors and shall be reviewed by the management responsible for the area audited. Conditions that require prompt corrective action shall be reported

immediately to the management of the audited organization. Audit findings shall be reviewed with the audited organizations at the closing meeting.

18.2.7 Reporting

The audit report shall be signed by the audit team leader and shall be issued to the audited organization within thirty calendar days of the audit in accordance with LANL QPs. The audit report shall include the following information, as appropriate:

- a description of the audit scope;
- identification of the auditors;
- identification of persons contacted during audit activities;
- a summary of audit results, including an evaluation of the effectiveness of the QA Program elements that were audited; and
- a description of each adverse audit finding in sufficient detail to enable the audited organization to take corrective action.

18.2.8 Response

Line management of the audited organization or activity shall investigate any audit finding, shall determine any root cause, shall schedule corrective action that include measures to prevent recurrence, and shall notify the QAS in writing of action taken or planned within thirty calendar days of receipt of the audit report. The adequacy of audit responses shall be evaluated by the QAS.

18.2.9 Follow-Up Action

Follow-up action, including reaudits of specific areas, shall be taken to determine whether corrective action has been accomplished as scheduled and shall be verified by the auditing organization. Audit results shall be analyzed by QAS to identify quality trends. The results of the analysis shall be reported to responsible management for review, assessment, and appropriate action.

18.2.10 Records

Audit records shall include

- identification of the organizations, activities, or items audited and the individuals contacted during the audit;
- a description of any deficiencies, nonconformances, or potential quality problems; and
- audit plans, audit reports, written replies, and the record of completed corrective actions and close-out of the audit.

Qualification records for auditors and lead auditors shall be established and maintained. Records for all auditors shall be updated annually.

18.3 Surveys

The audit program shall be supplemented by survey activities. The purpose of a survey shall be to monitor or observe items or activities to verify conformance to specified requirements. These surveys may be conducted by the QAS and/or a QAL on a scheduled and/or random basis.

Surveys shall be conducted in accordance with QPs. Surveys shall be scheduled and conducted based on the activity's relative effect on or importance to the YMP. All deficiencies, nonconformances, and potential quality problems identified during surveys shall be documented and monitored to ensure and verify that effective corrective action is made.

18.3.1 Planning

Surveys shall be performed according to written checklists or plans whenever practical. The planning documentation shall identify characteristics; define methods and acceptance criteria; and provide for the recording of objective evidence of results and the accuracy of the equipment necessary to perform the survey. Acceptance criteria related to surveillances may be as simple as to verify proper implementation of procedures or to verify conformance to requirements.

18.3.2 Reporting Independence

Survey personnel shall not report directly to the immediate supervisors who are responsible for the work being surveyed.

18.3.3 Records

Survey reports shall include the following:

- the identification of the organizations, activities, or items surveyed, including the names of persons contacted;
- the date of the survey;
- the name of the individual performing the survey;
- the survey criteria;
- any equipment used during the survey;
- a description of any deficiencies, nonconformances, and potential quality problems identified during the survey (nonconformances shall be handled per QAPP Section 15 or 16, as applicable);
- the survey results; and
- an acceptance statement related to the effectiveness of the QA Program as surveyed.

APPENDIX A

TERMS AND DEFINITIONS

ACCEPTANCE CRITERIA: Specified limits that are defined in codes, standards, or other requirements documents and placed on the characteristics of an item, process, or service.

ACCESSIBLE ENVIRONMENT: (1) the atmosphere, (2) the land surface, (3) surface water, (4) oceans, and (5) the portion of the lithosphere that is outside the controlled area.

ACTIVITIES THAT AFFECT QUALITY: Deeds, actions, work, or performance of a specific function or task. The Project Office QA Program applies to activities affecting the quality of all systems, structures, and components important to safety and to the design and characterization of barriers important to waste isolation. These activities include site characterization, facility and equipment construction, facility operation, performance confirmation, permanent closure, and decontamination and dismantling of surface facilities as they relate to items important to safety and barriers important to waste isolation. The QA Level I requirements of this QA Program apply to all activities affecting the quality of structures, systems, and components important to safety and engineered barriers important to waste isolation. These activities include designing (including such activities as safety analyses, laboratory testing of waste package materials to characterize their performance, and performance assessments), purchasing, fabricating, handling, shipping, storing, cleaning, erecting, installing, inspecting, testing, operating, maintaining, repairing, and modifying. These types of activities do not need to be identified as part of the Q-List nor do they require QA level assignment. However, activities related to natural barriers important to waste isolation shall be identified and listed on a Q-List. These activities include performance assessments, site characterization testing, and activities that may impact the waste isolation capability of the natural barrier. Examples are site characterization activities such as exploratory shaft construction, borehole drilling, and other activities that could physically or chemically alter properties of the natural barriers in an adverse way.

ACTIVITY: Any time-consuming effort (operation, task, function, or service) that influences or affects the achievement or verification of the objectives of the YMP as depicted in the WBS.

AP (YMP ADMINISTRATIVE PROCEDURE): An implementing procedure that identifies the interface control methods that govern Project-wide systems and are implemented by all Project participants. APs that implement QA requirements are identified with a "Q" suffix (i.e., AP-1.1Q).

AUDIT: A planned and documented activity performed to determine by investigation, examination, or evaluation of objective evidence the adequacy of, and compliance with, established procedures, codes, standards, instructions, drawings, and other applicable requirements, and the effectiveness of implementation. An audit should not be confused with surveillance or inspection activities performed for the sole purpose of process control or product acceptance.

AUTHENTICATION (QA RECORDS): Authentication is the act of attesting that the information contained within a document is accurate, complete, and appropriate to the work accomplished. Authentication is accomplished by one of the following methods: (1) a stamped, initialed, or signed, and dated document; (2) a statement by the responsible individual or organization; or (3) issuance of a document that is clearly identified as a statement by the reporting individual or organization. A document cannot become a QA record until it has been authenticated.

AUXILIARY SOFTWARE: (1) Software that may be easily and exactly verified and that performs a simple function such as conversion of units, change in data format, or plotting of data in support of primary analysis software. (2) A stream of commands or a sequence of streams of commands executed to utilize system

maintained software in which the system maintained software generates reportable results. Auxiliary software does not generate primary data.

BARRIER: Any material or structure that prevents or substantially delays the movements of water or radionuclides.

BASELINE: As used for computer software: (1) the stage of computer software at a completed and reviewed phase of the software life cycle; (2) approved documentation generated within, or as a result of, completing a phase of the software life cycle.

CERTIFICATE OF CONFORMANCE: A document signed by an authorized individual that certifies the degree to which items or services meet specified requirements.

CERTIFICATION: The act of determining, verifying, and attesting in writing to the qualifications of personnel, processes, procedures, or items in accordance with specified requirements.

CHARACTERISTIC: Any property or attribute of an item, process, or service that is distinct, describable, and measurable.

COMMERCIAL-GRADE ITEM: An item satisfying all of the following requirements:

- The item is not subject to design or specification requirements that are unique to mined geologic disposal systems.
- The item is to be ordered from the manufacturer/supplier on the basis of specifications set forth in the manufacturer's published product description (i.e., catalog).
- The item is used in applications other than mined geologic disposal systems.

COMPUTER CODE VERIFICATION: Assurance that a computer code correctly performs the operations specified in a numerical model (NUREG-0856). Usually accomplished by comparing code results with a hand calculation, to an analytical solution or approximation, or to a verified code designed to perform the same type of analysis (e.g., benchmarking).

COMPUTER CODE: A set of computer instructions for performing the operations specified in a numerical model.

COMPUTER MODEL VALIDATION: Assurance that a model, as embodied in a computer code, is a correct representation of the process or system for which it is intended (NUREG-0856) and usually accomplished by comparing code results with physical data or with a verified or validated code designed to perform the same type of analysis (e.g., benchmarking with a validated code). Peer review may be used for code validation if it is the only available means.

CONDITION ADVERSE TO QUALITY: An all-inclusive term used in reference to any of the following: failures, malfunctions, deficiencies, defective items, and nonconformances. A significant condition adverse to quality is one that, if not corrected, could have a serious effect on safety or operability.

CONFIGURATION MANAGEMENT: As used for computer software: (1) a system for the orderly control of software, including methods used for labeling, changing, and storing software and its associated documentation; (2) the systematic evaluation, coordination, approval or disapproval, and implementation of all approved changes in an item of software after establishment of its configuration.

CONSEQUENCE ANALYSIS: A method by which the consequences of an event are calculated and expressed in some quantitative way, e.g., money loss, deaths, or quantities of radionuclides released to the accessible environment.

CONTAINMENT: The confinement of radioactive waste within a designated boundary.

CONTAINMENT, PERIOD OF: The period during the first several hundred years following permanent closure of the geologic repository in which radiation and thermal levels are high and the uncertainties of ensuring repository performance are great. During this time, special emphasis is placed upon the ability to contain the wastes by waste packages within an engineered barrier system.

CONTRACTOR: An organization under contract to provide supplies, construction, or services.

CONTROLLED AREA: The surface location, which is to be marked by suitable monuments, that extends horizontally no more than five kilometers in any direction from the outer boundary of the underground facility and the underlying subsurface, which is an area that has been committed to use as a geologic repository and from which incompatible activities would be restricted following permanent closure. The controlled area is also known as the site.

CONVERSION REPORT: A written description of all modifications made to the original code or an externally available existing code after it is acquired.

CORRECTIVE ACTION: Measures taken to rectify conditions that are adverse to quality and, where necessary, to preclude repetition.

CORROBORATIVE DATA: Existing data used to support or substantiate other existing data.

CREDIBLE EVENT OR CREDIBLE ACCIDENT: An event or accident scenario that needs to be considered in the design of a geologic repository.

DESIGN: The act of developing designs for construction or of analyzing the performance of repository engineered structures, systems, components, and natural barriers. Design documentation includes, but is not limited to, drawings, specifications, test plans, design reports, test reports, system design descriptions, configuration status listings, design manuals, and manuals describing computer programs used for design or performance analysis.

DESIGN INPUT: Those criteria, parameters, bases, or other requirements upon which the detailed final design is based.

DESIGN OUTPUT: Documents, such as drawings and specifications, that define technical requirements of structures, systems, and components.

DESIGN PROCESS: Technical and management processes that commence with identification of design input and that lead to and include the issuance of design output documents.

DEVIATION: A departure from specified requirements.

DISCREPANCY: Condition adverse to quality; reference to any of the following: failures, malfunctions, deficiencies, defective items, and nonconformances.

DISPOSITION: The action taken to resolve a nonconforming condition and to restore acceptable conditions.

DOCUMENT: Any written or pictorial information describing, defining, specifying, reporting, or certifying activities, requirements, procedures, or results. A document is not considered to be a QA record until it satisfies the definition of QA record as defined in this appendix.

DOE: The U.S. Department of Energy or its duly authorized representatives.

ENGINEERED BARRIER SYSTEM: The waste package and the underground facility.

ENGINEERED ITEM: Any structure, system, or component identified in design documents as being a functional part of the completed facility.

EXISTING DATA: Data developed prior to the implementation of a 10 CFR 60, Subpart G, QA program by DOE and its contractors or data developed outside the DOE repository program, such as by oil companies, national laboratories, universities, or data published in technical or scientific publications. Existing data do not include information that is accepted by the scientific and engineering community as established facts (e.g., engineering handbooks, density tables, gravitational laws.)

EXTERNAL AUDIT: An audit of those portions of another organization's QA Program that is neither under the direct control nor within the organizational structure for the auditing organization.

FINAL DESIGN: Approved design output documents and approved changes thereto.

FUNCTIONAL CHARACTERISTICS: Those attributes of a repository or its structures, systems, and components that determine its performance with respect to safety, reliability, operability, and other design criteria established in the Office of Geologic Repositories Program or other Federal regulatory documents.

GEOLOGIC REPOSITORY: A system that is either intended to or may be used for the disposal of radioactive wastes in excavated geologic media. A geologic repository includes the geologic repository operations area and the portion of the geologic setting that provides isolation of the radioactive waste.

GEOLOGIC REPOSITORY OPERATIONS AREA: A high-level radioactive waste facility that is part of a geologic repository, including both surface and subsurface areas, in which waste-handling activities are conducted.

IMPORTANT TO SAFETY: Those engineered structures, systems, and components that are essential to the prevention or mitigation of an accident that could result in a radiation dose to the whole body, or any organ, of 0.5 rem or greater at or beyond the nearest boundary of the unrestricted area at any time until the completion of permanent closure.

IMPORTANT TO WASTE ISOLATION: The barriers that must meet the criteria for long-term performance of the engineered and natural barriers to prevent the release of radionuclides from the site to the accessible environment (i.e., for achieving the postclosure performance objectives in 10 CFR 60, Subpart E.)

INDOCTRINATION: Instruction provided to personnel to familiarize them with programmatic and work-oriented documents applicable to the assigned activity.

INSPECTION: Examination or measurement to verify whether an item or activity conforms to specified requirements.

INSPECTOR: A person who performs inspection activities to verify whether or not an item or activity conforms to specified requirements.

INTERNAL AUDIT: An audit of those portions of an organization's QA Program that is retained under its direct control and within its organizational structure.

ISOLATION: Inhibiting the transport of radioactive materials so that amounts and concentrations of this material entering the accessible environment will be kept within prescribed limits.

ITEM: An all-inclusive term that is used in place of any of the following: appurtenance, assembly, component, equipment, material, module, part, structure, subassembly, subsystem, system, unit, and prototype hardware. This term includes magnetic media and other materials that retain or support data.

LIFETIME RECORDS: QA records that furnish evidence of the quality and completeness of data, items, and activities affecting quality. All YMP QA records are classified lifetime records.

LOGBOOK: A document that may be used to provide a written record of repetitive activities performed in accordance with technical procedures. Examples include calibration, data runs, and inventory of controlled materials.

MATERIAL: A term that includes items plus any hardware or geologic samples either used in or resulting from research and development or site investigations on the YMP. Hardware and geologic specimens include, but are not limited to, test apparatus or equipment, special nuclear material, cores, geologic samples, and water and gas samples.

MEASURING AND TEST EQUIPMENT: Devices or systems used to calibrate, measure, gauge, test, or inspect in order to control or to acquire data to verify conformance to a specified requirement or to establish characteristics or values not previously known.

MODEL: A representation of a physical system, based on scientific principles and laws, that transforms a set of input information or data into another set of output information or data.

NONCONFORMANCE: A deficiency in characteristics, documentation, or procedure that renders the quality of an item or activity unacceptable or indeterminate.

NONMECHANISTIC FAILURES: Postulated failures that are not based on previously observed models or mechanisms but that are assumed to provide conservatism in safety assessments.

NUMERICAL METHOD: A procedure for solving a problem primarily by a sequence of arithmetic operations.

NUMERICAL MODEL: A representation of a process or system using numerical methods.

NEVADA TEST SITE SUPPORT CONTRACTOR: Organizations that are directly under contract to DOE/NV for activities at the Nevada Test Site and other locations.

OBJECTIVE EVIDENCE: Any documented statement of fact, other information, or record, either quantitative or qualitative, that pertains to the quality of an item or activity, based on observations, measurements, or tests that can be verified.

OPERATIONS, PERIOD OF: Includes the time during which the emplacement of wastes occurs; any subsequent period before permanent closure during which the emplaced wastes are retrievable; and permanent closure, which includes the sealing of shafts.

OVERVIEW: An analysis and assessment by management of the scope, status, adequacy, and effectiveness of the quality achievement and assurance activities for the YMP. Overview encompasses effectiveness assessments, technical reviews, readiness reviews, audits, and surveys, as appropriate.

OWNER: The person, group, company, agency, or corporation that has, or will have, title to the repository.

PARTICIPATING ORGANIZATION: This term applies to the following: (1) The government agencies external to the DOE, (2) national laboratories, and (3) organizations participating directly in YMP activities.

PEER: A peer is a person having technical expertise in the subject matter to be reviewed (or a critical subset of the subject matter to be reviewed) to a degree at least equivalent to that needed for the original work.

PEER REVIEW: A documented, critical review performed by peers who are independent of those who performed the work but who have technical expertise at least equivalent to those who performed the original work. Peer reviews are in-depth, critical reviews and evaluations of documents, material or data that require interpretation or judgement to verify or validate assumptions, plans, results or conclusions or when the conclusions, material or data contained in a report go beyond the existing state of the art. A peer review is an in-depth critique of assumptions, calculations, extrapolations, alternate interpretations, methodology and acceptance criteria employed, and of conclusions drawn in the original work. Peer reviews confirm the adequacy of work. In contrast to peer review, the term technical review refers to a review to verify compliance to predetermined requirements, industry standards or common scientific, engineering or industry practice.

PEER REVIEW GROUP: A peer review group is an assembly of peers representing an appropriate spectrum of knowledge and experience in the subject matter to be reviewed and should vary in size based on the subject matter and importance of the subject matter to safety or waste isolation.

PEER REVIEW REPORT: A documented in-depth report of the proceedings and findings of a peer review.

PERFORMANCE ALLOCATION: This term applies to the process of deriving subsystem and component performance goals from performance objectives. A systematic process of assigning confidence levels with their desired, associated performance goals for the mined geologic disposal systems, subsystems, and components.

PERFORMANCE ASSESSMENT: The process of quantitatively evaluating component and system behavior, relative to containment and isolation of radioactive waste, to determine compliance with the numerical criteria associated with 10 CFR Part 60.

PERFORMANCE CONFIRMATION: The program of tests, experiments, and analyses that will evaluate the accuracy and adequacy of the information used to determine with reasonable assurance that the performance objectives for the period after permanent closure will be met.

PERMANENT CLOSURE: The sealing of shafts and boreholes. Permanent closure represents the end of active human intervention with respect to the engineered barrier system.

PRIMARY DATA: Information that can be shown to have been acquired and controlled in a manner consistent with all applicable QA Level I requirements and that is necessary for the resolution of the NRC performance objectives of 10 CFR 60 in accordance with the YMP Issues Resolution Strategy. This includes information that has been qualified and accepted in accordance with Project Office AP-5.9Q, "Acceptance of Data and Data Interpretations not Developed Under the YMP QA Program."

PRINCIPAL INVESTIGATOR (PI): The individual who has the technical responsibility for a particular technical task. This responsibility includes, but is not limited to, planning and cost control, the day-to-day technical direction and control of the item or activity, and the assembly of a support team to accomplish the item or activity. This term may be synonymous with task leader or project engineer depending upon the YMP participant.

PROCEDURE: A document that specifies or describes the way in which an activity is to be performed.

PROCUREMENT DOCUMENT: Purchase requisitions, purchase orders, letters of intent, work authorization letters, drawings, contracts, specifications, instructions, or any document that provides a means for acquiring possession or ownership of items or right to the use of services by payment.

PURCHASER: The organization responsible for the establishment of procurement requirements and for the issuance, administration, or both, of procurement documents.

Q-LIST: A list of geologic repository engineered structures, systems, and components that have been determined to be important to safety, and engineered barriers important to waste isolation that must be covered under the QA requirements of 10 CFR 60, Subpart G.

QUALIFICATION (OF DATA): A formal process intended to provide a desired level of confidence that data are suitable for their intended use.

QUALIFICATION (PERSONNEL): The characteristics or abilities that are gained through education, training, or experience, which are measured against established requirements, such as standards or tests, that qualify an individual to perform a required function.

QUALIFICATION TESTING: Demonstration that an item meets design requirements.

QUALIFIED DATA: Data initially collected under a 10 CFR 60, Subpart G, QA Program or existing data qualified in accordance with Appendix G of this QAPP.

QUALIFIED PROCEDURE: An approved procedure that has been demonstrated to meet the specified requirements for its intended purpose.

QUALITY ACTIVITIES LIST: A list of those major activities conducted during site characterization, construction, operation, or closure that relate to natural barriers important to waste isolation. These activities, which must be covered under the program, include data gathering, performance assessments, and those activities that could affect a natural barrier's ability to isolate waste.

QUALITY ASSURANCE (QA): All those planned and systematic actions that are necessary to provide adequate confidence that the geologic repository and its subsystems or subcomponents will perform satisfactorily in service.

QUALITY ASSURANCE RECORD: An individual document or other item that has been executed, completed, and approved and that furnishes evidence of the (1) quality and completeness of data (including raw data), items, and activities affecting quality; (2) documents prepared and maintained to demonstrate implementation of programs (e.g., audit, surveillance, and inspection reports); (3) procurement documents; (4) other documents such as plans, correspondence, documentation of telecons, specification, technical data, books, maps, papers, photographs, and data sheets; (5) items such as magnetic media; and (6) other materials that provide data and document quality regardless of the physical form or characteristic. A completed record is a document or item (and documentation) that will receive no more entries, whose revisions would normally

consist of a reissue of the document (or documentation), and that is signed and dated by the originator and, as applicable, by approval personnel.

QUALITY ASSURANCE LEVEL I: Those radiological health- and safety-related items and activities that are important to either safety or waste isolation and that are associated with the ability of a geologic nuclear waste repository to function in a manner that prevents or mitigates the consequences of a process or event that could cause undue risk to the radiological health and safety of the public. Items and activities important to safety are those engineered structures, systems, components, and related activities essential to the prevention or mitigation of an accident that could result in a radiation dose either to the whole body or to any organ of 0.5 rem or greater, either at or beyond the nearest boundary of the unrestricted area, at any time until the completion of the permanent closure of the repository. Items and activities important to waste isolation are those barriers and related activities that must meet the criteria that address postclosure performance of the engineered and natural barriers to inhibit the release of radionuclides. The criteria for items or activities important to safety and waste isolation are found in 10 CFR 60 and 40 CFR 191.

QUALITY ASSURANCE LEVEL II: Those activities and items related to the systems, structures, and components that require a level of QA sufficient to provide for reliability, maintainability, public and repository worker nonradiological health and safety, repository worker radiological health and safety, and other operational factors that would have an impact on DOE and YMP concerns and the environment.

QUALITY ASSURANCE LEVEL III: Those activities and items not classified as QA Levels I or II.

QUALITY ASSURANCE PROGRAM PLAN (QAPP): The document that describes the organization's QA Program and the applicable QA requirements and that defines how compliance with the QA criteria will be accomplished.

RADIOACTIVE WASTE: High-level waste (HLW) and other radioactive materials that are received for emplacement in a geologic repository.

READINESS REVIEW: An independent, systematic, documented review to determine and inform management of the readiness to advance from one phase, process, or activity into another. Readiness reviews are used to coordinate many elements and provide attention to detail and to ensure that the project is ready to proceed to the comprehensive review of a total project or a particular segment of a project.

RECEIVING: Taking delivery of an item at a designated location.

RELIABILITY ANALYSIS: An analysis that estimates the reliability of a system or component.

REPAIR: The process of restoring a nonconforming characteristic to a condition such that the capability of an item to function reliably and safely is unimpaired, even though that item still does not conform to the original requirement.

REPOSITORY: See Geologic Repository Operations Area.

RETRIEVAL: The act of intentionally removing radioactive waste from the underground location at which the waste had been emplaced previously for disposal.

REWORK: The process by which a nonconforming item or activity is made to conform to the original requirements by completion or correction utilizing existing approved procedures.

RIGHT OF ACCESS: The right of a purchaser or designated representative to enter the premises of a supplier for the purpose of inspection, survey, or QA audit.

SCENARIO: An account or sequence of a projected course of action or event.

SCIENTIFIC INVESTIGATION: Any research, experiment, test, study, or activity that is performed for the purpose of investigating the natural barriers or the man-made aspects of the geologic repository, including the overall design of the facilities and the waste package. This will include, but will not be restricted to, all geologic, tectonic, seismologic, hydrologic, climatologic, geochemical, chemical, geophysical, physical, geomechanical, mechanical, meteorological, metallurgical, environmental, socioeconomic, and transportation studies of activities that are performed for, or in support of, the investigation, exploration, site characterization, development of design bases, licensing, construction, operation, monitoring, performance evaluation, and closure of the geologic repository.

SCIENTIFIC NOTEBOOK: A document which may be used to provide a written record of the results of scientific investigations and experiments when the work involves a high degree of professional judgment or trial and error methods, or both. These notebooks may be used in lieu of a technical procedure.

SERVICE: The performance of activities that include, but are not limited to, site characterization, design, fabrication, investigation, inspection, nondestructive examination, repair, or installation.

SITE: Location of the controlled area.

SITE CHARACTERIZATION: The program of exploration and research, both in the laboratory and in the field, undertaken to establish the geologic conditions and the ranges of parameters of a particular site that are relevant to the procedures under 10 CFR 60. Site characterization includes borings, surface excavations, excavation of exploratory shafts, limited subsurface lateral excavations and borings, and *in situ* testing at depth as needed to determine the suitability of the site for a geologic repository. It does not include preliminary borings and geophysical testing needed to decide whether or not site characterization should be undertaken.

SOFTWARE: A set of computer operations specified in any programming language that can be translated unambiguously into machine language. (Operations specified in machine language are also software.)

SOFTWARE-DEVELOPMENT LIFE CYCLE: A method of project planning and documentation for the development of a software product. Life cycle allows optimal traceability regarding the goals, restrictions, decisions made, and current progress of a code.

SPECIAL PROCESS: A process, the results of which are highly dependent on the control of the process, the skill of the operators, or both, and in which the specified quality cannot be readily determined by inspection or test of the product.

SUPPLIER: Any individual or organization under contract to provide items or services to the DOE/NV, to a participating organization, or to a Nevada Test Site support contractor for YMP activities.

SURVEY: The act of monitoring or observing to verify whether or not an item or activity conforms to specified requirements.

TECHNICAL PROJECT OFFICER (TPO): The individual within each YMP participant's organization who has been assigned overall responsibility for the organization's scope or work as detailed in the WBS.

TECHNICAL REVIEW: A documented traceable review performed by qualified personnel who are independent of those who performed the work but who have technical expertise at least equivalent to those who performed the original work. Technical reviews are in-depth, critical reviews, analyses, and evaluation of documents, material, or data that require technical verification and/or validation for applicability, correctness, adequacy, and completeness.

TESTING: An element of verification that is used to determine the capability of an item to meet specified requirements by subjecting the item to a set of physical, chemical, environmental, or operating conditions.

TRACEABILITY: The ability to track the history, application, or location of an item and like items or activities by means of recorded identification.

TRAINING: In-depth instruction provided to personnel to develop and demonstrate initial proficiency in the application of selected requirements, methods, and procedures and to adapt to changes in technology, methods, or job responsibilities.

TRAVELER: A document that accompanies and tracks the progress of an item, sample, or activity.

UNDERGROUND FACILITY: The underground structure, including openings and backfill materials, but excluding shafts, boreholes, and their seals.

UNRESTRICTED AREA: Any area to which access is not controlled for purposes of protection of individuals from exposure to radiation and radioactive materials, and any area used for residential quarters.

USE-AS-IS: A disposition that is permitted for a nonconforming item or service when it can be established that the item is satisfactory for its intended use.

VALIDATION (QA RECORDS): Validation is the act of reviewing a document or document package to ensure it is complete, authenticated, reproducible, and microfilmable.

VERIFICATION: The act of reviewing, inspecting, testing, checking, auditing, or otherwise determining and documenting whether items, processes, services, or documents conform to specified requirements.

WAIVER: Documented authorization to depart from specified requirements.

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT OFFICE: The organization to which the DOE/NV has assigned the responsibility of administering and coordinating the activities of various participating organizations and Nevada Test Site support contractors associated with the YMP.

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT PARTICIPANTS: An all-inclusive term used to describe (generically) the various organizations involved in the YMP. This term includes the Project Office, participating organizations, and Nevada Test Site support contractors. These contractors are required to have a Project Office-approved QAPP for the conduct of their activities.

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT PERSONNEL: All DOE participating organizations and Nevada Test Site support contractor personnel involved in YMP activities.

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT QUALITY ASSURANCE PLAN (QAP): The document that describes the planned, systematic QA requirements that are applicable to the YMP.

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT WORK BREAKDOWN STRUCTURE (WBS) DICTIONARY: A controlled document that establishes a product-oriented framework for organizing and defining work to be accomplished.

WASTE PACKAGE: The waste form and any containers, shielding, packing, and other absorbent materials immediately surrounding an individual waste container.

APPENDIX B

B.0 DESIGN INPUTS

B.1 Introduction

Design inputs include many characteristics and functions of an item or system. For a more detailed discussion on design control activities, see QAPP Section 3.

B.2 Applicable Design Inputs

Applicable design inputs are identified and documented, and their selection is reviewed and approved by the responsible design and QA organizations. The purpose of the QA review is to ensure that the documents are prepared, reviewed, and approved in accordance with documented procedures and QA requirements. Changes in approved design inputs, including the reason for the changes, are identified, documented, approved, and controlled by the responsible design organization. Although these inputs vary depending on the application, LANL or its subcontractor will consider the following list of inputs as they apply to specific items or systems of the repository:

- basic functions of each structure, system, and component;
- performance requirements such as capacity rating and system output;
- codes, standards, and regulatory requirements, including the applicable issue, agenda, or both;
- design conditions such as pressure, temperature, fluid chemistry, and voltage;
- loads such as seismic, wind, thermal, and dynamic;
- environmental conditions anticipated during storage, construction, and operation, including pressure, temperature, humidity, corrosiveness, site elevation, wind direction, nuclear radiation, electromagnetic radiation, and duration of exposure;
- interface requirements, including definition of the functional and physical interfaces involving structures, systems, and components;
- material requirements, including such items as compatibility, electrical insulation properties, protective coating, and corrosion resistance;
- mechanical requirements such as vibration, stress, shock, and reaction forces;
- structural requirements covering such items as equipment foundations and pipe supports;
- hydraulic requirements such as pump net positive suction heads, allowable pressure drops, and allowable fluid velocities;
- chemistry requirements, including provisions for sampling and limitations on water chemistry;
- electrical requirements such as source of power, voltage, raceway requirements, electrical insulation, and motor requirements;
- layout and arrangement requirements;
- operational requirements under various conditions, including repository start-up, normal repository operation, repository emergency operation, special or infrequent operation, system abnormal or emergency operation, and repository decontamination, decommissioning, and dismantling;
- instrumentation and control requirements, including indicating instruments, controls, and alarms required for operation, testing, and maintenance (other requirements such as the type

of instrument, installed spares, range of measurement, and location of indication are included);

- access and administrative control requirements for repository security;
- redundancy, diversity, and separation requirements of structures, systems, and components;
- requirements for failure effects of structures, systems, and components, including a definition of those events and accidents that these structures, systems, and components must be designed to withstand;
- test requirements, including preoperational and subsequent periodic in-service tests and the conditions under which these tests will be performed;
- accessibility, maintenance, repair, and in-service inspection requirements for the repository, including the conditions under which these inspections will be performed;
- personnel requirements and limitations, including the qualification and number of personnel available for repository operation, maintenance, testing, and inspection, and radiation exposures to the public and repository personnel;
- transportability requirements, including size and shipping weight, limitation, and Interstate Commerce Commission regulations;
- fire protection or resistance requirements;
- handling, storage, cleaning, and shipping requirements;
- other requirements to prevent undue risk to the health and safety of the public;
- materials, processes, parts, and equipment suitable for application;
- safety requirements for preventing injury to personnel, including radiation safety to restrict the use of dangerous materials, escape provisions from enclosures, and grounding of electrical systems;
- quality control and QA requirements;
- reliability requirements of structures, systems, and components, including their interactions, which may impair functions that are important to safety;
- interface requirements between repository equipment and operation and maintenance personnel; and
- requirements for criticality control and accountability of nuclear materials.

APPENDIX C

C.0 REQUIREMENTS FOR THE QUALIFICATION OF INSPECTION AND TEST PERSONNEL

LANL does not currently conduct any YMP activities to which these requirements apply.

APPENDIX D

D.0 REQUIREMENTS FOR THE QUALIFICATION OF NONDESTRUCTIVE EXAMINATION PERSONNEL

LANL does not currently conduct any YMP activities to which these requirements apply.

APPENDIX E

E.0 LIST OF TYPICAL QUALITY ASSURANCE RECORDS

The following is a list of typical LANL YMP QA records. The YMP retention period for these records is defined as lifetime. QA records shall be specified, prepared, and maintained in accordance with QAPP Section 17 and the LANL QPs. In addition, the control of QA records shall comply with the applicable requirements of Project Office AP-1.7Q, "Yucca Mountain Project QA Records Management."

E.1 Site Characterization

- Surveys of the underground facility excavations, shafts, and boreholes referenced to readily identifiable surface features.
- Description of the materials encountered.
- Geologic maps and geologic cross section.
- Locations and amounts of seepage.
- Instrument locations, readings, analysis, and reports for *in situ* testing.
- Technical specifications.
- Sample extraction location maps.
- Site Characterization Report.
- Environmental Assessment.
- Peer review documentation.
- Test plans and procedures, and results.
- Data reduction, evaluations, analyses, and reports for
  - — Geomorphology.
  - — Stratigraphy.
  - — Tectonics.
  - — Seismicity.
  - — Geoengineering.
  - — Hydrology.
  - — Geochemistry.
  - — Climatology and Meteorology.
- Environmental Impact Statement.
- Environmental Report.

E.2 Design Records

- Applicable codes and standards used in design.
- Design drawings.
- Design calculations and records of checks.
- Approved design change requests.
- Design deviations.
- Design reports.
- Design verification data.
- Design specifications and amendments.
- Safety analysis report.
- Stress reports for code items.
- Systems descriptions.
- Systems process and instrumentation diagrams.
- Technical analysis, evaluations, and reports.

E.3 Procurement Records

- Procurement specifications.
- Purchase order including amendments.

E.4 Manufacturing Records for Procured Equipment

- Applicable code data reports.
- As-built drawings and records. (Note: As-built drawings and records shall correctly identify the installed condition of the item. The type of as-built drawings and records to be maintained shall be specified.)
- Certificate of compliance.

E.5 Installation and Construction Records

E.5.1 Receiving and Storage - Nonconformance Reports

E.5.2 General

- Scientific investigation planning documents.
- QA level assignment documents.
- Review and approval documents including comments and resolution.
- Data interpretation and analysis documents.
- Software configuration management, including software QA requirements in accordance with Section 3.3 of this QAPP.
- Scientific notebooks and logbooks.
- Detailed technical procedures.
- Audit and survey documentation.
- Verification documentation.
- Recommendations.
- Close-out verification.
- Personnel qualification documents.
- Peer reviews.
- Design analysis.
- Design change control.
- Anomalous conditions encountered.
- Nonconformance reports.
- Corrective action reports.
- Audit reports.
- Trending reports.

APPENDIX F
F.0 REQUIREMENTS FOR THE QUALIFICATIONS OF QUALITY ASSURANCE PROGRAM AUDIT PERSONNEL

F.1 Introduction

All LANL YMP activities are subject to scheduled and planned internal and external audits to ensure that procedures and activities comply with the overall QA Program and to determine the program's effectiveness. This appendix provides requirements for the qualification of lead auditors. A lead auditor organizes and directs audits, reports audit findings, and evaluates corrective actions. This appendix also provides amplified requirements for the qualifications of individuals, hereinafter referred to as auditors, who participate in an audit, including technical specialists, management representatives, and auditors-in-training.

F.1.1 Qualification of Auditors

LANL and its subcontractors will establish the qualifications for audit personnel and the requirements for the use of technical specialists to accomplish the auditing of QA Programs. Personnel selected for QA auditing assignments will have experience or training commensurate with the scope, complexity, or special nature of the activities to be audited. Auditors will either have or will be given appropriate training or orientation to develop their competence to perform required audits. The competence of personnel to perform the various auditing functions will be developed by one or more of the methods listed below.

F.1.1.1 Orientation

Orientation will provide a working knowledge and understanding of this document and procedures used by LANL and its subcontractors for implementing audits and reporting results.

F.1.1.2 Training Programs

Training programs will provide general and specialized instruction in audit performance. General training will include fundamentals, objectives, characteristics, organization, performance, and results of quality auditing. Specialized training will include methods of examining, questioning, evaluating, and documenting specific audit items and methods of closing audit findings.

F.1.1.3 On-the-Job Training

On-the-job training, guidance, and counseling will be under the direct supervision of the lead auditor. Such training will include planning, performing, reporting, and follow-up action involved in conducting audits.

F.1.2 Qualification of Lead Auditors

An individual will meet the requirements listed below before being designated a lead auditor.

F.1.2.1 Communication Skills

The prospective lead auditor will have the capability to communicate effectively, both orally and in writing. These skills will be attested to in writing by LANL.

F.1.2.2 Training

Prospective lead auditors will have training to the extent necessary to ensure their competence in auditing skills. Training will be given in the following areas based upon management evaluation of the particular needs of each prospective lead auditor:

- knowledge and understanding of this document, 10 CFR 60, and other nuclear- and/or DOE-related codes, standards, regulations, and regulatory guides, as applicable to the YMP;
- general structure of QA Programs and applicable elements as defined in this document;
- auditing techniques of examining, questioning, evaluating, and reporting; methods of identifying and following up on corrective action items and procedures for closing out audit findings;
- audit planning in the functions related to quality for the following activities: site characterization (scientific investigations), design, purchasing, fabrication, handling, shipping, storage, cleaning, erection, installation, inspection, testing, statistics, nondestructive examination, maintenance, repair, operation, modification of nuclear facilities or associated components, and safety aspects of the nuclear facility.
- on-the-job training, including applicable elements of the audit program.

F.1.2.3 Audit Participation

The prospective lead auditor will have participated in a minimum of five QA audits within a period of time not to exceed three years before the qualification date. One of the audits will be a nuclear facility QA audit that will be made within the year before qualification.

F.1.2.4 Examination

The prospective lead auditor shall pass an examination that shall evaluate his comprehension of, and ability to apply, the body of knowledge identified in Paragraph F.1.2.2 of this appendix. The test may be oral, written, practical, or any combination of the three types. If any portion of the examination is oral, written documentation of the oral examination questions/content shall be maintained. The development and administration of the examination shall be in accordance with Section F.3 of this appendix.

F.2 Maintenance of Qualification

F.2.1 Maintenance of Proficiency

Lead auditors will maintain their proficiency through regular and active participation in the audit process; review and study of codes, standards, procedures, instructions, and other documents related to a QA Program and program auditing; and participation in training programs. Based on an annual assessment, LANL may extend the qualifications, require retraining, or require requalification. These evaluations will be documented.

F.2.2 Requalification

Lead auditors who fail to maintain their proficiency for a period of two years or more shall require requalification. Requalification will include retraining in accordance with the requirements of Subsection F.1.2.2 of this appendix, re-examination in accordance with Subsection F.3.2 of this appendix, and participation as an auditor in at least one nuclear facility QA audit.

F.3 Administration

F.3.1 Organizational Responsibility

Training of auditors will be LANL's responsibility. LANL or its subcontractors will select and assign personnel who are independent of any direct responsibility for the performance of the activities that they will audit. The lead auditor will, before commencing the audit, concur that assigned personnel collectively have experience or training commensurate with the scope, complexity, or special nature of the activities to be audited.

F.3.2 Qualification Examination

The development and administration of the examination for a lead auditor required by Subsection F.1.2.4 of this appendix is LANL's responsibility. LANL may delegate this activity to an independent certifying agency but will retain responsibility for the examination and its administration for conformance to this document. The integrity of the examination will be maintained by LANL or by a certifying agency through appropriate confidentiality of files and, where applicable, proctoring of examinations. LANL will retain copies of the objective evidence regarding the type or types and content of the examination or examinations.

F.4 Certification of Qualification

Each lead auditor will be certified by LANL as being qualified to lead audits. As a minimum, this certification will document the following:

- the employer's name;
- the lead auditor's name;
- the date of certification or recertification;
- the basis of qualification (i.e., education, experience, communication skills, training, and examination); and
- the signature of LANL's designated representative who is responsible for such certification.

APPENDIX G

G.0 REQUIREMENTS FOR QUALIFICATION OF EXISTING DATA NOT GENERATED UNDER A QUALITY ASSURANCE PROGRAM MEETING THE REQUIREMENTS OF 10 CFR 60, SUBPART G

G.1 General

This appendix provides the requirements for the qualification for existing data that will be needed to support a license application, which have not been initially generated under a QA Program meeting the requirements of 10 CFR 60, Subpart G.

G. 2 Methods for Qualification of Existing Data

Four methods or combinations of methods are acceptable for the process of qualifying existing data:

- The execution of the peer review process in accordance with the requirements of Appendix J of this QAPP.
- The use of corroborating data that are defined as existing data used to support or substantiate other existing data. Inferences drawn to corroborate the existing data shall be clearly identified, justified, and documented. The level of confidence associated with corroborating data is related to the quality of the program under which it developed and the number of independent data sets. The amount of corroborating data needed shall be dealt with on a case-by-case basis in the documented reviews for qualifications.
- The use of confirmatory testing, which is defined as testing conducted under a 10 CFR 60, Subpart G, QA Program that investigates the properties of interest (e.g., physical, chemical, geologic, mechanical) of an existing database. One example of confirmatory testing is testing conducted under the same environmental conditions and with similar or the same procedures, test material, and equipment as the original test that generated the existing data. Another type of confirmatory testing is testing conducted by different test methods and equipment but that still investigates the same parameter of interest. The amount of confirmatory testing required shall be dealt with on a case-by-case basis in the documented reviews for qualification.
- Demonstrating that the existing data were collected under a QA Program equivalent to a 10 CFR 60, Subpart G, QA Program.

G.3 Selection and Documentation of Qualification Methodology

When the methods indicated in the last three bullets of Section G.2 are utilized to qualify existing data, a technical review shall be conducted to support the quality of the data. Additional confidence/credibility can be achieved when a combination of methods is used.

Documentation of the decision process shall provide an auditable trail of all factors used in arriving at the choice of the qualification method(s), and the decision as to the qualification of the existing data. The level of confidence in the existing data shall be commensurate with the intended use of the data. Attributes which shall be considered in the qualification process are

- Qualifications of personnel or organizations generating the data are comparable to qualification requirements of personnel generating similar data under the approved 10 CFR 60, Subpart G, program.
- The technical adequacy of equipment and procedures used to collect and analyze the data.
- The extent to which the data demonstrate the properties of interest (e.g., physical, chemical, geologic, mechanical).
- The environmental conditions under which the data were obtained, if germane to the quality of

data.

- The quality and reliability of the measurement control program under which the data were generated.
- The extent to which conditions under which the data were generated may partially meet Subpart G.
- Prior uses of the data and associated verification processes.
- Prior peer or other professional reviews of the data and their results.
- Extent and reliability of the documentation associated with the data.
- Extent and quality of corroborating data or confirmatory testing results.
- The degree to which independent audits of the process that generated the data were conducted.
- The importance of the data to showing that the proposed repository design meets the performance objectives of 10 CFR 60, Subpart E.
- Replication of test results.

Note: Additional guidance related to this subject can be found in NUREG-1298, "Qualification of Existing Data for High-Level Nuclear Waste Repositories" (February 1988).

APPENDIX H

H.0 REQUIREMENTS FOR COMPUTER SOFTWARE

H.1 Objectives and Scope

The purpose of this appendix is to describe the requirements for the development, management, control, and documentation of the software used to support the LANL YMP. The software requirements of this appendix are intended to ensure software quality and to provide the NRC with part of the basis on which it will evaluate the soundness of the software used.

This appendix supplements and shall be used in conjunction with Section 3.3 of the QAPP. Appendix A contains the definitions for the terms used in this appendix.

The requirements set forth in this appendix apply to computer software used to produce or manipulate data that is used directly in site characterization and performance assessment analyses and in the design, analysis, and operation of repository structures, systems, and components. LANL shall prepare QPs that ensure the requirements of this appendix are implemented in a consistent and systematic manner. The extent to which these requirements apply is related to the nature, complexity, and importance of the software applications and are defined in LANL's Software QA Plan (SQAP).

H.2 Verification and Validation

Verification and validation methodologies will be described in the SQAP. QPs will be used to implement the chosen methodology. Verification and validation of software shall be performed before the use of such software to perform technical calculations in support of site characterization, performance assessment analyses, and the design, analysis, and operation of repository structures, systems, and components. In those cases where this requirement cannot be met, the portion or portions of software that have not been verified or validated shall be identified and controlled. In all cases, the verification and validation of software shall be completed before relying on the software to support the license application.

H.2.1 Software Verification

Verification plans shall use methods such as analyses, demonstrations, and test runs to ensure that the software adequately and correctly performs all intended functions and to provide confidence that it does not perform any function that, either by itself or in combination with other functions, could degrade the entire system.

Verification activities shall be performed according to QPs and relative to specific hardware configurations prior to the use of the software in support of the license application. The amount of verification activity shall be determined by the type and complexity of the software. The results of verification shall be documented according to the QP.

H.2.2 Model Validation

Model validation activities shall be performed according to QPs and will demonstrate that the models embodied in computer software are adequate representations of the process or system for which they are intended. Validation shall be accomplished by comparing software results with verified and traceable data obtained from laboratory experiments, field experiments or observations, or *in situ* testing. Specific sets of data used in the validation process shall be identified, and justification for their use shall be documented. When data are not available

from the sources mentioned above, alternative approaches may be used and shall be documented. Alternative approaches may include peer review and comparisons with the results of similar analyses performed with verified software. The results of model validation, including an evaluation of the degree of validity of the model, shall be documented in accordance with the QP.

Model validation shall be accomplished prior to the use of the software-generated data in final reports used for licensing. Data generated prior to model validation may be used in reports with the designation that the data was generated using models that have not been validated.

H.3 Software Configuration Management

A software configuration management system shall be described in the SQAP with implementation direction contained in QPs to ensure positive identification of software and control of all software baseline changes and provide appropriate documentation to the YMP local records center.

H.3.1 Configuration Identification

Software configuration baseline items shall be identified at the appropriate phase of each code's software life cycle. Approved changes in a baseline shall be added to the baseline as updates. A baseline and its updates shall specify the most recent software configuration. A labeling system for configuration items shall be implemented that

- uniquely identifies each software configuration item or version identifier,
- identifies changes in software configuration items by revision identifiers, and
- facilitates placement of the software configuration item in a relationship with other configuration items.

H.3.2 Configuration Change Control

Changes in software configuration items shall be formally controlled and documented. This documentation shall contain a description of the change, the identification of the originating organization, the rationale for the change, and the identification of affected baselines and software configuration items. The change will be formally evaluated by a qualified individual or organization with the ability to approve or disapprove the proposed change. Assurance shall be provided that only authorized changes are made in software baselines and software configuration items.

H.3.3 Configuration Status Accounting

The information needed to manage software configuration items shall be recorded and reported. This information shall include the approved configuration identification, the status of formal proposals for changes in software configuration items, the implementation status of approved changes, and all information to support the functions of configuration identification and configuration control.

H.4 Discrepancy Reporting and Corrective Action

QPs shall be prepared to describe the software discrepancy and corrective action reporting system. This discrepancy reporting system shall be integrated with the configuration management system to ensure formal processing of discrepancy resolutions.

Software discrepancy procedures shall ensure that, as a minimum,

- defects are documented and evaluated for possible corrective action,
- defects are assessed for impact on previous applications,
- corrections are reviewed and approved before changes in software configuration items are entered in baselines, and
- preventive and corrective actions provide for appropriate notification of organizations to which controlled copies have been distributed.

H.5 Media Control and Security

Physical media containing the images of software shall be physically protected to prevent their inadvertent damage, degradation, or loss.

H.6 Software Acquisition, Procurement, and Transfer

Procedures shall be established for controlling the acquisition or procurement of computer software from an outside organization and for the transfer of computer software to an outside organization.

Software requests by LANL groups shall include appropriate criteria to enable the software received to comply, as much as possible, with the requirements of this QAPP. Requirements not satisfied at the time the software is received shall be completed by the organization in the appropriate phase of the applicable software life cycle. For those requirements that are not satisfied, the reasons shall be documented and distributed to the users.

Configuration management requirements shall apply to acquired or procured software using the product originally received as the initial baseline. Configuration management records shall document any conversions, modifications, configuration changes, or additional software needed to make the software functional.

Configuration management change controls shall be established for documenting the conversion of software to be used on a computer system, and/or peripheral hardware, other than that for which it was designed. Conversion includes all modifications and tests made to input/output or the source code or additional software written to run the original software on the new system. Software conversion shall be documented and maintained for the specific version of the software and the computer system on which it is installed. Software conversion changes shall be evaluated and activities performed in accordance with the appropriate configuration management system elements.

H.7 Software Quality Assurance Plan

A LANL SQAP shall be prepared that describes the software design, test and configuration management system for software used to support the design of a geologic repository. This description shall provide criteria for the application of Appendix H requirements, based on the complexity and importance of the software used; indicate the methods used to develop computer program requirements and translate those requirements into a detailed design and executable code; describe the documentation to be prepared, reviewed, and maintained during software design, code implementation, test, and use; state the methodology for establishing a software baseline and change control system, which includes change control tracking throughout the life of the software; describe the process used for verification and validation of the software developed; and identify procedures used for reporting and documenting software discrepancies, including sources, evaluating impacts of discrepancies on previous calculations, and determination of the appropriate corrective actions.

The LANL SQAP shall identify the

- organizational responsibilities for the management, application, control, and acquisition of software, and the interfacing of these activities;
- software products to which the SQAP applies;
- software development life cycle model used, including documentation.
- minimum required documentation;
- software configuration management system used;
- verification and validation methodologies; and
- software review procedures and the attendant documentation.

H.8 Software Life Cycle

Each LANL group shall use the life cycle controls below.

LANL shall adhere to a software life cycle model that requires that software development or acquisition proceed in a traceable, planned, and orderly manner. The relative emphasis placed on the phases of the software life cycle will depend on the nature, complexity, importance, and intended application of the software.

Documentation is required as defined in this portion of the appendix and described in the SQAP. All software documentation is considered to be a QA record.

Documentation produced during software development, acquisition, implementation, testing, and use shall receive the appropriate reviews as described in the SQAP.

Reviews of software life cycle activities shall be performed, as applicable, for each life cycle phase completed. The QPs used for reviews shall identify the reviewers and their responsibilities.

The documentation for all reviews shall contain a record of review comments and the personnel responsible for comment resolution. After review comments have been resolved, the approved documents shall be updated and placed under configuration management.

The following are the life cycle elements that shall apply, as appropriate for the software, as defined, interpreted, and described in the LANL SQAP.

H.8.1 Life Cycle Requirements Phase

During this phase, requirements that pertain to functionality, performance, design constraints, attributes, and external interfaces of the completed software shall be specified, documented, and reviewed. These requirements include the following characteristics:

- format and language that is understood by the programming organization and the user,
- enough detail to allow for objective verification,
- adequate definition to provide for the response of the software to the identified input data, and
- the information necessary to design the software without prescribing the software design itself.

Software requirements documentation shall outline the requirements that the software must fulfill. A specific capability of software should be referred to as a requirement only if its

achievement can be verified by a prescribed method. The requirements shall address the following, as applicable to the software application:

- functionality—the functions the software is to perform;
- performance—the time-related issues of software operation such as speed, recovery time, and response time;
- design constraints imposed on implementation—any elements that will restrict design options;
- attributes—non-time-related issues of software operation such as portability, correctness, security, and maintainability; and
- external interfaces—interactions with other participants, hardware, and other software.

The review of software requirements is performed at the completion of the software requirements documentation. This review shall ensure that the requirements are complete, verifiable, and consistent. The review shall also ensure that sufficient detail is available to facilitate definition of the software design or acquisition.

H.8.2 Life Cycle Design Phase

During the design phase, a software design based on the requirements shall be specified, documented, and systematically reviewed. The design specifies the overall structure (control and data flow) and the reduction of the overall structure to physical solutions (algorithms, equations, control logic, and data structures). The design may necessitate the modification of the requirements documentation.

Verification activities during this phase consist of, but are not limited to

- the planning for design-based test cases,
- the review and analysis of the software design, and
- the verification of the software design.

Software design documentation shall address the following, as applicable to the software application:

- a description of the major components of the software design as they relate to the requirements of the software requirements specification;
- a technical description of the software with respect to control flow, data flow, control logic, and data structure;
- a description of the allowable and tolerable ranges for inputs and outputs;
- the design described in a manner that is easily traceable to the software requirements; and
- a description of life cycle verification activities.

The software design review shall be held at the completion of the software design documentation. This review includes an evaluation of the technical adequacy of the design approach and ensures that the design satisfies all the requirements in the requirements documentation. Depending on the complexity of the software design, the design may require multiple design reviews.

H.8.3 Life Cycle Coding Phase

During this phase, the design is translated into a programming language and the software is debugged. Only minor design issues, if any, should be resolved at this phase.

Verification activities during this phase shall consist of

- the possible modification of test cases necessitated by design changes made during coding and
- the examination of source code listings to ensure adherence to coding standards and conventions.

Software coding documentation shall address the following, as applicable:

- source code listings,
- revised requirements documents, and
- revised design documents.

Any design changes made in the requirements and design-phase documents shall be assessed to determine the impact on the design. The revised requirements and design-phase documents shall be reviewed at the same review level as that performed for the original documents.

The software coding phase review is an evaluation to determine that the requirements and design specifications are implemented in the completed code. The review is conducted prior to verification and validation.

H.8.4 Life Cycle Testing Phase

The testing phase consists of verification activities. Software verification will be essentially completed during this phase. The verification activities include

- execution of the test cases and evaluation of the results,
- evaluation of the completed software to ensure adherence to the requirements, and
- preparation of a report describing the results of software verification.

Life cycle testing activities shall be documented. Software testing documentation includes a plan that describes the tasks and criteria for accomplishing the verification of the software in this phase. The documentation also specifies the hardware and system software configuration(s) for which the software is designed. In those cases where testing is used to ensure that requirements have been met in the software design, test documentation shall provide traceability from requirements to design as implemented in the code. This documentation also includes a report on the results of the execution of the life cycle verification activities. The report includes the results of all previous reviews, audits, and tests, and a summary of the status of the software.

Model validation will be conducted in accordance with Section H.2.2 of this appendix. Because model validation is dependent on application, model validation may not be completed at this stage.

The software testing review is an evaluation of the adequacy of completed software life cycle verification activities and model validation plans. The review results in an approval of verification and validation documentation.

H.8.5 Life Cycle Installation and Checkout Phase

During this phase, the software may become part of a system that incorporates other software components, hardware, and production data. The process of integrating the software with other components may consist of installing hardware, installing the program, reformatting or creating data bases, and verifying that all components have been included.

Testing activities during this phase shall consist of the execution of test cases for installation and integration. Test cases from earlier phases may be used for installation testing.

H.8.6 Life Cycle Application and Maintenance Phase

During the application and maintenance phase, the software is approved for operational use. Further activities may consist of maintenance of the software to identify and remove latent errors (corrective maintenance), response to new or revised requirements (perfective maintenance), or adaptation of the software to changes in the software environment (adaptive maintenance). Software modifications shall be approved, documented, tested, and controlled in accordance with software configuration management requirements. User notification of changes and corrections is a vital aspect of the maintenance phase.

LANL shall establish procedures for controlling the application of software that performs technical calculations in support of site characterization and performance assessment analyses and for the design, analysis, and operation of repository structures, systems, and components. These software applications shall be reviewed and approved to ensure that the software selected is applicable to the problem being solved and that all input data and assumptions are valid and traceable.

LANL shall include in QPs, methods for documenting software applications that perform technical calculations to ensure that these applications and the results of these applications may be independently reproduced.

Procedures shall be established for reviewing these applications to provide reasonable assurance that the software used is appropriate for the intended application and that the results produced are accurate. Documentation appropriate for a given application or analysis shall include the computer code, the input data, the assumptions or approximations used to develop the input data, and appropriate user documentation for performing the application or analysis.

H.9 Mandatory Documentation

The following documentation is mandatory as applicable to the particular software and is maintained as a QA record (reference Section 3.3.1 of the QAPP):

- software summary form,
- software requirements,
- software design and change,
- software verification and validation,
- continuing documentation and code listings,
- mathematic and numerical models,
- user's manual,
- code assessment and support, and
- configuration management support.

Mandatory documents shall be reviewed in accordance with LANL review procedures. These documents shall comply will the documentation requirements of NUREG-0856.

APPENDIX I

I.0 REQUIREMENTS FOR THE IDENTIFICATION OF ITEMS AND ACTIVITIES TO BE INCLUDED ON THE Q-LIST

I.1 Introduction

This appendix provides requirements for the identification of items important to safety and the identification of items and activities important to waste isolation. These items and activities are subject to the highest quality assurance level (QA Level I) of this QAPP and shall be listed on a Q-List.

The Project Office will prepare the appropriate AP or APs for determining the items and activities to be placed on the Q-List. This procedure will describe the Probabilistic Risk Assessment (PRA) techniques and performance allocation methods used for identifying Q-listed items and activities.

I.2 Quality Assurance Criteria for Licensing

The purpose of the geologic repository program is to permanently dispose of high-level nuclear waste. In order to obtain a license for receipt and possession of radioactive material at the geologic repository, it must be demonstrated that the repository system will function as required to protect health and safety of the public and the environment. Requirements for licensing a repository to meet this goal are specified in 10 CFR 60. These requirements describe the performance objectives and other technical criteria to ensure safe operation during waste emplacement and retrieval (if necessary), as well as effective containment and long-term isolation of waste following permanent closure of the geologic repository. The QA Level I requirements of this QA Plan specify the QA Program for those items and related activities important to safety and/or waste isolation to ensure that their characterization, design, construction, and operation comply with the requirements of 10 CFR 60.

I.2.1 Criteria for the Q-List and Quality Activities List

The QA Level I requirements of this QAPP apply to items and activities important to safety and/or waste isolation. As derived from 10 CFR 60 (60.152), this QA Program is based on the eighteen criteria of 10 CFR 50, Appendix B. These criteria address, in general terms, the basic elements of a QA Program, such as organization, design control, test control, inspection, and records management. As noted in 10 CFR 60.152, these criteria are supplemented as necessary to meet the specific requirements of the repository program. In addition to the QA Level I requirements of this QAPP, items important to safety and the waste package are subject to the design criteria of 10 CFR 60.131(b) and 60.135, respectively.

I.2.2 Criteria for Non-Q-List Items

Certain items that are not important to safety and/or waste isolation shall also be addressed in the license application to demonstrate compliance with 10 CFR 60 requirements, such as those associated with meeting the design criteria in 10 CFR 131 (a) for protection of worker health safety. While these items are not subject to the QA Level I requirements of this QAPP, QA Level II requirements shall be applied. Additional guidance related to this subject can be found in NUREG-1318 (April 1988), paragraph 5.1(b).

I.2.3 Data Not Collected Under a 10 CFR 60, Subpart G, QA Program

All data collection, interpretations, analyses, and other work to be used to support findings related to "important to safety" and/or "waste isolation" in the licensing process shall be technically and procedurally defensible. "Existing data" shall be qualified in accordance with

the requirements of Appendix G of this QAPP. In addition to existing data, some materials that may be important to safety and/or waste isolation may already have been purchased prior to implementation of a 10 CFR 60, Subpart G, QA Program. Supporting documentation on these materials (e.g., the technical specifications and QA records) shall be reviewed to determine whether they meet the technical and QA requirements for their designated function. If not, they shall be "qualified" for use to ensure they will perform their intended function.

I.3 Identification of Items Important to Safety

Items important to safety are those items essential to the prevention or mitigation of an accident that could result in a radiation dose to the whole body, or any organ, of 0.5 rem or greater at or beyond the nearest boundary of unrestricted area at any time until the completion of permanent closure (10 CFR 60.2). The 0.5-rem value is, therefore, the threshold for determining what structures, systems, and components shall be on the Q-List as items important to safety. The rationale for placing a system, structure, or component on the Q-List is to provide added assurance, via application of rigorous QA/quality control and design requirements, that they should perform their designated function.

PRA shall be used to the extent practicable, to support the identification of structures, systems, and components important to safety in the license application. Use of this approach for the operations phase of the high-level waste program is consistent with the approach prescribed by the Environmental Protection Agency standard (40 CFR 191) for the overall system containment following emplacement of waste in a geologic repository. In cases where data are limited, engineering judgment and conservative bounding assumptions shall be used. Conservative assumptions shall include nonmechanistic failures where information and/or experience are not adequate to reliably determine failure modes and accident scenarios. However, nonmechanistic failures need not be considered where failure modes and mechanisms are understood and failure rates can be determined.

Operator actions or errors that could initiate accidents shall be identified in PRAs or other analysis. These shall be controlled to minimize the probability of occurrence. Other activities that are subject to QA Level I requirements, such as designing, inspecting, and purchasing, will not be identified in PRAs but shall be controlled in accordance with QA Level I requirements.

PRAs shall utilize the following techniques:

- System modeling to depict the combination of safety function and system successes or failures that constitute accident scenarios. Two modeling techniques that may be used are event tree analysis, which identifies the sequence of events that may result in an accident, and fault tree analysis, which determines how failures in safety systems may occur. Both techniques are analytical tools which organize and characterize potential accidents in a methodical manner.

- An event tree defines a comprehensive set of accident sequences that encompasses the effects of all realistic and physically possible potential accidents. By definition, an initiating event is the beginning point in the sequence. Hence, a comprehensive list of accident-initiating events shall be compiled to ensure that the event trees properly depict all important sequences.

- The fault tree examines the various ways in which a system designed to perform a safety function can fail. Each safety system identified in the event tree as involved in an accident shall be examined to determine how failures of components within that system could cause the failure of the entire system.

- If failure of a mitigating system should contribute to an offsite dose, individual components within the mitigating system shall be reviewed, using fault tree analysis, to determine the effect of their failure on performance of the overall system. For example, individual

components in the ventilation system which may need to be analyzed include dampers, motors, and filters.

- Consequence analysis of accident scenarios identified in event/fault tree analyses to determine the amount and kind of radionuclides that may reach the unrestricted area and contribute to an off-site dose. Consequence analysis includes identification of a source term for radioactive releases and evaluation of mechanisms for movement and deposition of radioactive materials released from the high-level waste facility. The energy, magnitude, and timing of radiological releases resulting from various accidents shall be considered in this analysis.

- Analysis to assess the effect of uncertainties in the data base and uncertainties arising from modeling assumptions on the PRA findings. The insights gained in the analysis about features that are significant contributors to risk can provide qualitative understanding into system performance.

Additional guidance related to the assessment of preclosure accidents can be found in NUREG-1318 (April 1988), paragraph 5.2(a).

I.3.1 Redundancy

The use of redundant structures, systems, and components is a method of providing additional assurance that necessary safety functions will be performed if an accident occurs and that the accident dose limit will not be exceeded. In a redundant system, the failure of one train of the system shall not comprise or prevent the associated safety function from being performed. For the HLW repository, 10 CFR 60 [60.131(b) (5) (ii)] addresses requirements for redundancy. The items needed to provide redundancy of items important to safety shall also be on the Q-List.

I.3.2 Use of Previously Established Guidelines and Standards

Many guidelines and standards have been developed in the nuclear power reactor program and other nuclear programs that may be applicable for the geologic repository program. For example, there are regulatory guides covering design basis earthquakes, floods, and tornado wind velocities that may be used in the design of the HLW facility and developing the Q-List. While some of these guidelines and standards may not be directly applicable to a geologic repository, they shall be considered, to the extent practicable, to eliminate the need to develop new approaches.

I.3.3 Retrieval

The option for retrieval of waste is addressed as a performance objective in 10 CFR 60.111(b). If retrieval is found to be necessary, analyses of retrieval operations shall be conducted at that time to identify Q-List items.

I.4 Identification of Items and Activities Important to Waste Isolation

The term "important to waste isolation" refers to engineered and natural barriers that will be relied on to meet the containment and isolation performance objectives of 10 CFR 60, Subpart E. Four of the performance objectives for waste isolation after permanent closure are stated in 10 CFR 60.112 and 60.113 and include

- groundwater travel time,
- waste package containment period,
- maximum yearly release rate from the engineered barrier system,

- the overall system performance objective in 10 CFR 60.112 for release of radioactive materials to the accessible environment (the Environmental Protection Agency standard in 40 CFR 191).

The items and activities important to waste isolation shall include

- Components of the engineered barrier system relied on to meet the performance objectives.
- Elements of the natural barrier system (e.g., host rock and geochemical retardation characteristics) relied on to meet the performance objectives.
- Activities necessary to demonstrate that the performance objectives will be met, including collection of data to characterize the site or performance of engineered barriers.
- Activities in the preclosure phase that could affect postclosure performance.

The broad performance objectives for waste isolation provide some flexibility in allocating credit among the various components of the natural and engineered barrier systems to meet each objective. For example, a 300- to 1,000-year lifetime for the waste package might be achieved by a combination of performance from each of the components in the waste package or by a single component, such as the canister. The allocation of performance among the various components of the natural and engineered barrier system for each performance objective will provide the basis for determining which barriers are important to waste isolation. Performance assessments shall be conducted on these barriers to ascertain that those relied on will meet the waste isolation and containment performance objectives of 10 CFR 60. The initial allocations of performance will provide a basis for determining what site characterization testing will be needed. The initial allocations of performance among the barriers is likely to change based on the results of performance assessments using data collected during site characterization.

It is expected that most of the data collected during the site characterization phase can potentially be used in the license application performance assessments. During the early phase of characterization in particular, when little is known about the site and the importance of data characterizing it, data collection activities shall be controlled in accordance with the QA Level I requirements of this QAPP. However, there may be cases where it is known that data are not needed for performance assessments or will be duplicated later in accordance with QA Level I requirements of this QAPP and, therefore, would not have to be performed in accordance with QA Level I requirements at this time. For example, scoping tests or tests to examine the feasibility and appropriateness of a data collection technique may not need to be performed in accordance with the QA Level I requirements of this QAPP.

Note: Additional guidance related to this subject can be found in NUREG-1318, "Technical Position on Items and Activities in the High-Level Waste Geologic Repository Program Subject to Quality Assurance Requirements" (April 1988).

APPENDIX J

J.0 REQUIREMENTS FOR PEER REVIEW

J.1 Introduction

This appendix provides the requirements regarding the applicability of peer reviews, the structure of peer review groups, acceptability of peers, and the conduct and documentation of peer reviews.

J.2 Applicability of Peer Review

A peer review shall be used when the adequacy of information (e.g., data, interpretations, test results, design assumptions) or the suitability of procedures and methods essential to showing that the repository system meets or exceeds its performance requirements with respect to safety and waste isolation cannot otherwise be established through testing, alternate calculations or reference to previously established standards and practices.

In general, the following conditions are indicative of situations in which a peer review shall be considered.

- Critical interpretations or decisions will be made in the face of significant uncertainty, including the planning for data collection, research, or exploratory testing.
- Decisions or interpretations having significant impact on performance assessment conclusions will be made.
- Novel or untried testing, plan, procedure, and/or analyses are, or will be, utilized.
- Detailed technical criteria or standard industry procedures do not exist or are being developed.
- Results of tests are not reproducible or repeatable.
- Data or interpretations are ambiguous.
- Data adequacy is questionable—such as, data may not have been collected in conformance with an established QA program.

A peer review shall be used when the adequacy of a critical body of information can be established by alternate means, but there is disagreement within the cognizant technical community regarding the applicability or appropriateness of the alternate means.

J.3 Structure of Peer Review Group

The number of peers composing a peer review group shall vary, commensurate with the following:

- the complexity of the work to be reviewed,
- its importance to establishing that safety or waste isolation performance goals are met,
- the number of technical disciplines involved,
- the degree to which uncertainties in the data or technical approach exist, and
- the extent to which differing viewpoints are strongly held within the applicable technical and scientific community concerning the issues under review.

The collective technical expertise and qualifications of peer review group members shall span the technical issues and areas involved in the work to be reviewed, including any differing bodies of

scientific thought. The potential for technical or organizational partiality shall be minimized by selecting peers to provide a balanced peer review group. Technical areas more central to the work to be reviewed shall receive proportionally more representation in the peer review group.

J.4 Acceptability of Peers

The technical qualification of the peer reviewers in their review areas shall be at least equivalent to that needed for the original work under review and shall be the primary consideration in the selection process. Each peer shall have recognized and verifiable technical credentials in the technical area that the peer has been selected to review.

Members of the peer review group shall be independent of the original work to be reviewed. Independence in this case means that the peer was not involved as a participant, supervisor, technical reviewer, or advisor in the work being reviewed and, to the extent practical, has sufficient freedom from funding considerations to ensure the work is impartially reviewed. In some cases (i.e., funding considerations) it may be difficult to meet the independence criteria without reducing the technical quality of the peer review. When the independence criteria cannot be met, a documented rationale shall be included in the peer review report.

J.5 Peer Review Process

Since the peer review process may vary from case to case, a peer review plan shall be prepared prior to initiating a peer review. The peer review plan shall describe the work to be reviewed, the size and spectrum of the peer review group, and the suggested method and schedule necessary to produce a peer review report.

The peer review group shall evaluate and report on

- validity of assumptions,
- alternate interpretations,
- uncertainty of results and consequences if incorrect,
- appropriateness and limitations of methodology and procedures,
- adequacy of application,
- accuracy of calculations,
- adequacy of requirements and criteria, and
- validity of conclusions.

Documentation shall be prepared to indicate the results of meetings, deliberations, and activities of the peer review process.

J.6 Peer Review Report

A report documenting the results of the peer review shall be prepared and issued under the direction of the peer review group chairperson. The report shall be signed by each peer review group member. The peer review report shall include the following:

- a clear description of the work or issue that was peer reviewed;
- conclusions reached by the peer review process;

- individual statements by peer review group members reflecting dissenting views or additional comments, as appropriate; and
- listing of the peers and the technical qualification and evidence of independence for each peer, including potential technical and/or organizational partiality.

Note: Additional guidance related to this subject can be found in NUREG-1297, "Peer Review for High-Level Nuclear Waste Repositories" (February 1988).

APPENDIX K

K.0 FORMAT AND CONTENT REQUIREMENTS FOR SITE CHARACTERIZATION PLAN STUDY PLANS

K.1 Purpose and Objectives of Studies

- Describe the information that will be obtained in this study. Briefly discuss how this information will be used.
- Provide the rationale and justification for the information to be obtained by the study. The study plan can be justified by (1) a performance goal and a confidence level in that goal (developed via the performance allocation process and results that will be described elsewhere in the Site Characterization Plan); (2) a design goal and a confidence level in that goal (design goals beyond those related to performance issues); and (3) direct Federal, State, and other regulatory requirements for specific studies. Where relevant performance or design goals actually apply at a higher level than the study (e.g., where the goals apply to a group of studies), describe the relationship between this study and that higher level goal.

K.2 Rationale for Selected Study

- Provide the rationale and justification for the selected tests and analyses (including standard tests). Indicate the alternative test and analytical methods from which they were selected, including options for type of test, instrumentation, data collection and recording, and alternative analytical approaches. Describe the advantages and limitations of the various options, and
- Provide the rationale for the selected number, location, duration, and timing of tests with consideration to various sources of uncertainty (e.g., test method, interference with other tests, and estimated parameter variability). This rationale should also identify reasonable alternatives; summarize reasons for not selecting these alternatives, and reference, if available, reports that evaluate alternatives considered.
- Describe the constraints that exist for the study, and explain how these constraints affect selection of test methods and analytical approaches. Factors to be considered include
  - potential impacts on the site from testing;
  - whether the study needs to simulate repository conditions;
  - required accuracy and precision of parameters to be measured with test instrumentation;
  - limits of analytical methods that will use the information from the tests;
  - capability of analytical methods to support the study;
  - time required versus time available to complete the study;
  - the scale of the phenomena, especially the limitations of the equipment relative to the scale of the phenomena to be measured and the applicability of studies conducted in the laboratory to the scale of the phenomena in the field;
  - interrelationships of tests involving significant interference with other tests and how plans have been designed or sequenced to address such interference; and
  - interrelationships involving significant interference among tests and exploratory shaft facility design and construction, as appropriate (refer to Section 8.4 of the Site Characterization Plan or its references for specific Exploratory Shaft Facility design information).

K.3 Description of Tests and Analyses

- Because studies comprise tests and analyses, provide the following for each type of test:
  - Describe the general approach that will be used in the test. Describe key parameters that will be measured in the test and the experimental conditions under which the test will be conducted. Indicate the number of tests and their locations (e.g., spatial location relative to

the site, Exploratory Shaft Facility elements, repository layout, stratigraphic units, depth, and test location).

- Summarize the test methods. Reference any standard procedures (e.g., ASTM or API) to be used. If any of the procedures to be used are not standard or if a standard procedure will be modified, summarize the steps of the test, how it will be modified, and reference the technical procedures that will be followed during the test. If procedures are not yet available, indicate when they will be available. Indicate the QA level and provide a rationale for any tests that are not judged to be QA Level I. Reference the applicable specific QA requirements that will be applied to the test.
- Specify the tolerance, accuracy, and precision required in the test, where appropriate.
- Indicate the range of expected results of the test and the basis for those expected results.
- List the equipment required for the test and describe briefly any such equipment that is special.
- Describe techniques to be used for data reduction and analysis of the results.
- Discuss the representativeness of the test including why the test results are considered representative of future conditions or the spatial variability of existing conditions. Also indicate limitations and uncertainties that will apply to the use of the results.
- Provide illustrations such as maps, cross sections, and facility design drawings to show the locations of tests and schematic layouts of tests.
- Show the relationship of the test to the set performance goals and confidence levels.

- For each type of analysis, do the following:
  - State the purpose of the analysis, indicating the testing or design activity being supported. Indicate what conditions or environments will be evaluated and any sensitivity or uncertainty analyses that will be performed. Discuss the relationship of the analysis to the set performance goals and confidence levels.
  - Describe the methods of analysis including any analytical expressions and numerical models that will be employed.
  - Reference the technical procedures document that will be followed during the analysis. If procedures are not yet available, indicate when they will be available. Indicate the QA level that will be applied to the analysis and provide a rationale for any analyses that are not judged to be QA Level I. Reference the applicable QA requirements.
  - Identify the data input requirements of the analysis.
  - Describe the expected output and accuracy of the analysis.
  - Describe the representativeness of the analytical approach (e.g., with respect to spatial variability of existing conditions and future conditions) and indicate limitations and uncertainties that will apply to the results.

K.4 Application of Results

- Briefly discuss where the results from the study will be used for the support of other studies (performance assessment, design, and characterization studies).
- For performance assessment uses, refer to specific performance assessment analyses (described in Section 8.3.5 of the Site Characterization Plan) that will use the information produced from the studies described above, and refer to any use of the results for model validation.
- For design uses, refer to, or describe, where the information from the study described above will be used in construction equipment design and development, and engineering system design and development (e.g., waste package, repository engineered barriers, and shaft and borehole seals).
- For characterization uses, refer to, or describe, where the information from the study described above will be used in planning other characterization activities.

K.5 Schedule and Milestones

- Provide the durations of, and interrelationships among, the principal activities associated with conducting the study (e.g., preparation of test procedures, test set-ups, testing, data analyses, preparation of reports), and indicate the key milestones, including decision points associated with the study activities.
- Describe the timing of this study relative to other studies and other program activities that will affect, or will be affected by, the schedule for completion of the subject study.
- Dates for activities or milestones including durations and interrelationships, for the study plans will be provided. These should reference the master schedules provided in Section 8.5 of the Site Characterization Plan.

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JUN 05 1990

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ISSUANCE OF SURVEILLANCE REPORT YMP-SR-90-028 RESULTING FROM YUCCA MOUNTAIN PROJECT OFFICE (PROJECT OFFICE) QUALITY ASSURANCE (QA) SURVEILLANCE OF COMPLIANCE AND IMPLEMENTATION OF LOS ALAMOS NATIONAL LABORATORY (LOS ALAMOS) IMPLEMENTING PROCEDURES PERTAINING TO ORGANIZATION, QA PROGRAM, INSTRUCTIONS, PROCEDURES, PLANS AND DRAWINGS, CORRECTIVE ACTIONS, AUDITS, AND SURVEILLANCES NN1-1990- 3427)

Enclosed is the report of QA Surveillance YMP-SR-90-028 conducted by Project Office QA at Los Alamos from May 7 through 9, 1990.

During the surveillance, five observations were generated. These observations are enclosed with this report. Written responses to the observations are due within 20 working days of the transmittal date of this letter. Please address your responses to Nita J. Brogan, Science Applications International Corporation, Las Vegas, Nevada.

If you have any questions, please contact either James Blaylock at (702) 794-7913 or (FTS 544-7913) or Mario R. Diaz at (702) 794-7974 or (FTS 544-7974) of the Yucca Mountain Project QA staff.

James Blaylock for
Donald G. Horton, Director
Quality Assurance
Yucca Mountain Project Office

YMP:JB-3565

Enclosure:
QA Surveillance Report YMP-SR-90-028
w/encls

cc w/encl:
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YUCCA MOUNTAIN PROJECT OFFICE

QUALITY ASSURANCE SURVEILLANCE REPORT

OF

LOS ALAMOS NATIONAL LABORATORY

SURVEILLANCE REPORT NUMBER YMP-SR-90-028

CONDUCTED MAY 7 THROUGH MAY 9, 1990

ACTIVITIES SURVEILLED:

ORGANIZATION, QUALITY ASSURANCE PROGRAM, INSTRUCTIONS, PROCEDURES, PLANS AND DRAWINGS, CORRECTIVE ACTION, AUDITS, AND SURVEILLANCES

Prepared by: _____ Date: 6-4-90
Maris R. Diaz
Quality Assurance Engineer
Yucca Mountain Project Office

Approved by: James B. Blaylock for _____ Date: 6/4/90
Donald G. Horton, Director
Quality Assurance
Yucca Mountain Project Office

ENCLOSURE

1.0 INTRODUCTION

This report contains the results of a Yucca Mountain Project Office (Project Office) Quality Assurance (QA) surveillance of Los Alamos National Laboratory (Los Alamos) at Los Alamos, New Mexico. The surveillance was to verify compliance and implementation of their approved Los Alamos implementing procedures in the areas of Organization, QA Program, Instructions, Procedures, Plans and Drawings, Corrective Actions, Audits, and Surveillances.

2.0 PURPOSE AND SCOPE

The main purpose and scope of this surveillance was to follow-up on the commitments obtained through Los Alamos Audit No. 90-01 performed by the Project Office during the period from March 26 through 30, 1990. This also permitted verification of the progress obtained in the affected areas. In addition, implementation of the following criteria/procedures was verified for compliance:

QAPP, Revision 4.3, Section 1.0, Organization
QAPP, Revision 4.3, Section 2.0, Quality Assurance Program
QAPP, Revision 4.3, Section 5.0, Instructions, Procedures, Plans, and Drawings
QAPP, Revision 4.3, Section 16.0, Corrective Action

TWS-QAS-QP-15.2, Revision 1, Deficiency Reporting
TWS-QAS-QP-18.1, Revision 2, Audits
TWS-QAS-QP-18.2, Revision 1, Surveys
TWS-QAS-QP-18.3, Revision 1, Auditor Qualification

3.0 SURVEILLANCE PERSONNEL

Mario R. Diaz, QA Engineer, Yucca Mountain Project, Las Vegas, Nevada

4.0 SUMMARY OF SURVEILLANCE REPORT

This surveillance constituted a review of the status of a new organizational chart and the revision of the implementing procedures for QA training activities, Corrective Action, Audits, and Surveillance activities.

Overall implementation of the Los Alamos Corrective Action Program is considered indeterminate. Los Alamos shoulld provide close management attention to this area. Implementation of Audits and Surveillances is considered marginal. Other areas covered during this surveillance appear to be in accordance with Los Alamos management's schedule and commitments to previous Standard Deficiency Reports (SDRs).

Five Observations were documented to indicate the inadequacies found in areas covered by the surveillance.

5.0 PERSONNEL CONTACTED

R. Herbst, Technical Project Officer, Los Alamos
H. Nunes, QA Project Leader, Los Alamos
J. Day, QA Support Contractor--Verification, Los Alamos Technical Associates (LATA)
L. Schempp, Program Development Coordinator, Los Alamos
P. Chavez, Training Clerk, LATA
G. Gainer, QA Engineer, LATA
D. Williams, Records Processing Clerk, LATA
B. Gutierrez, Resident File Custodian,
K. West, Project Leader, Los Alamos

6.0 SYNOPSIS OF OBSERVATIONS

OBS No. YMP-SR-90-028-01	Time limitation to approve audit schedule does not exist.
OBS No. YMP-SR-90-028-02	Audits have not been performed in accordance with dates established in audit schedule.
OBS No. YMP-SR-90-028-03	Surveillance reports do not have time limitation on issuance.
OBS No. YMP-SR-90-028-04	The Los Alamos/Yucca Mountain Project program does not have sufficient audit personnel to perform required internal and external audits.
OBS No. YMP-SR-90-028-05	No method or system exists to address significant conditions related to quality that are reported to Los Alamos by third parties.

7.0 REQUIRED ACTIONS

Los Alamos is requested to provide responses to Observations OBS No. YMP-SR-90-028-01, 02, 03, 04, and 05 within 20 working days from the transmittal of the observations.

8.0 RECOMMENDATIONS

Los Alamos management personnel should closely monitor the implementation of procedural requirements and commitments related to Project Office Audit No. 90-01 for the following reasons:

1. To ensure that implementation has been carried out (a) in accordance with applicable requirements or commitments and (b) a timely manner.

2. To ensure prompt action when modifications to the aforementioned documents are deemed necessary to reflect actual implementation conditions.

3. To ensure that documentation of any action related to Item No. 2 (above) is transmitted to the Project Office, thus allowing proper coordination with surveillances required as part of the follow-up to Project Office Audit No. 90-01.

YUCCA MOUNTAIN PROJECT OFFICE

N-QA-012
4/89

[1] YMPO OBSERVATION NO. 90-028-01

Completed by Originating Organization

[2] Noted During: YMP-SR-90-028	[3] Identified By: M. Diaz	[4] Date: 05/09/90
[5] Organization: Los Alamos	[6] Person(s) Contacted: H. Nunes	[7] Response Due Date is 20 Days from Date of Transmittal

[8] Discussion:

Time limitations to officially approve the audit schedule does not exist. This situation could add unnecessary delays to the implementation of audits in certain areas that require auditing early enough to assure effective quality assurance.

[9] QAE/Lead Auditor	Date	[10] Branch Manager	Date
Mario Diaz	5/30/90	Cathie Hampton for	6-5-90

Completed by Respondee

[11] Response:

[12] Signature: Date:

Completed by QA Org.

[13] Response Receipt Acceptable ☐	
Initiator Date	QA/Lead Auditor Date

[14] Remarks:

YUCCA MOUNTAIN PROJECT OFFICE

N-QA-012
4/89

[1] YMPO OBSERVATION NO. 90-028-02

Completed by Originating Organization

[2] Noted During: YMP-SR-90-028	[3] Identified By: M. Diaz	[4] Date: 05/08/90
[5] Organization: Los Alamos	[6] Person(s) Contacted: H. Nunes	[7] Response Due Date is 20 Days from Date of Transmittal

[8] Discussion:

Audits have not been performed in accordance with dates already established through the audit schedule. Documented evidence of the changes(s) to the schedule are vague and inadequately updated.

[9] QAE/Lead Auditor	Date	[10] Branch Manager	Date
Mario Dán	5-30-90	[signature]	6-5-90

Completed by Respondee

[11] Response:

[12] Signature: Date:

Completed by QA Org.

[13] Response Receipt Acceptable ☐

Initiator	Date	QA/Lead Auditor	Date

[14] Remarks:

YUCCA MOUNTAIN PROJECT OFFICE

N-QA-012
4/89

[1] YMPO OBSERVATION NO. 90-028-03

Completed by Originating Organization

[2] Noted During: YMP-SR-90-028	[3] Identified By: M. Diaz	[4] Date: 05/08/90
[5] Organization: Los Alamos	[6] Person(s) Contacted: H. Nunes/R. Herbst	[7] Response Due Date is 20 Days from Date of Transmittal

[8] Discussion:

Surveillance reports do not have a time limitation for issuance. If they are used to supplement audits they should have the same time limitation in order to be similar and be able to produce an appropriate corrective action development.

[9] QAE/Lead Auditor	Date	[10] Branch Manager	Date
Mario Diaz	5-30-90	Catherine Haynes	5-30-90

Completed by Respondee

[11] Response:

[12] Signature: Date:

Completed by QA Org.

[13] Response Receipt Acceptable ☐	
Initiator / Date	QA/Lead Auditor / Date

[14] Remarks:

YUCCA MOUNTAIN PROJECT OFFICE

N-QA-012
4/89

[1] YMPO OBSERVATION NO. 90-028-04

Completed by Originating Organization

[2] Noted During: YMP-SR-90-028	[3] Identified By: M. Diaz	[4] Date: 05/08/90
[5] Organization: Los Alamos	[6] Person(s) Contacted: H. Nunes R. Herbst	[7] Response Due Date is 20 Days from Date of Transmittal

[8] Discussion:

To date, Los Alamos YMP program does not have an adequate amount of auditors and lead auditors to perform all scheduled 1990 internal and external audits.

[9] QAE/Lead Auditor	Date	[10] Branch Manager	Date
[signature]	5-30-90	[signature]	6-3-90

Completed by Respondee

[11] Response:

[12] Signature: Date:

Completed by QA Org.

[13] Response Receipt Acceptable ☐	
Initiator Date	QA/Lead Auditor Date

[14] Remarks:

YUCCA MOUNTAIN PROJECT OFFICE

N-QA-012
4/89

[1] YMPO OBSERVATION NO. 90-028-05

Completed by Originating Organization

[2] Noted During: YMP-SR-90-028	[3] Identified By: M. Diaz	[4] Date: 05/09/90
[5] Organization: Los Alamos	[6] Person(s) Contacted: R. Herbst H. Nunes	[7] Response Due Date is 20 Days from Date of Transmittal

[8] Discussion:

A method or system used to address significant condition(s) adverse to quality, reported by third parties to Los Alamos, does not exist. (i.e., responsible personnel in charge of acknowledging its reportability, type of forms or documentation to be used, responsible personnel in charge of evaluating and approving the action(s) required to bring the condition(s) under adequate controls in order to permit an easy tracking mechanism and adequate closing time limitation).

[9] QAE/Lead Auditor	Date	[10] Branch Manager	Date
Mario Díaz	5-30-90	[signature] for 6-5-90	

Completed by Respondee

[11] Response:

[12] Signature: Date:

Completed by QA Org.

[13] Response Receipt Acceptable ☐	
Initiator Date	QA/Lead Auditor Date

[14] Remarks:

Department of Energy
Yucca Mountain Project Office
P. O. Box 98608
Las Vegas, NV 89193-8608

WBS 1.2.9.3
QA

AUG 09 1990

Richard J. Herbst
Technical Project Officer
for Yucca Mountain Project
Los Alamos National Laboratory
University of California
N-5, Mail Stop J521
P.O. Box 1663
Los Alamos, NM 87545

ISSUANCE OF SURVEILLANCE REPORT YMP-SR-90-032 RESULTING FROM YUCCA MOUNTAIN PROJECT OFFICE (PROJECT OFFICE) QUALITY ASSURANCE (QA) SURVEILLANCE OF LOS ALAMOS NATIONAL LABORATORY (LOS ALAMOS) (NN1-1990- 3716)

Enclosed is the report of QA Surveillance YMP-SR-90-032 conducted by the Project Office QA at Los Alamos from July 9 through July 12, 1990.

Also enclosed is SDR 562 generated as a result of the surveillance. Please identify the corrective actions to be taken and implemented to correct the deficiency by completing blocks 14 through 18, as appropriate, of the SDR.

Response to the SDR is due within 20 working days of the date of this letter. Any extension to this due date must be requested in writing with appropriate justification prior to the due date. Please send the original of your response to Nita J. Brogan, Science Applications International Corporation, Las Vegas, Nevada.

Your cooperation and timely response is appreciated. If you have any questions, please contact either Catherine E. Hampton at (702) 794-7973 or FTS 544-7913, or Charles C. Warren at (702) 794-7248 or FTS 544-7248 of the Yucca Mountain Project QA staff.

for Donald G. Horton, Director
Quality Assurance
Yucca Mountain Project Office

QA:CEH-4451

Enclosure:
QA Surveillance Report YMP-SR-90-032

cc w/encl:
D. E. Shelor, HQ (RW-30) FORS
M. J. Regenda, FSN, Mercury, NV
C. O. Wright, H&N, Mercury, NV
H. P. Nunes, LANL, Los Alamos, NM
D. W. Short, LLNL, Livermore, CA
C. C. Warren, MACTEC, Las Vegas, NV
M. A. Fox, REECo, Mercury, NV
R. R. Richards, SNL, 6319, Albuquerque, NM
A. I. Arceo, SAIC, Las Vegas, NV, 517/T-06
N. J. Brogan, SAIC, Las Vegas, NV, 517/T-08
J. B. Harper, SAIC, Las Vegas, NV, 517/T-38
C. H. Prater, SAIC, Las Vegas, NV, 517/T-06
D. H. Appel, USGS, Denver, CO

cc w/o encl:
H. E. Valencia, LAAO
J. W. Hines, OQD, AL
A. R. Chernoff, MSD, AL
J. W. Gilray, NRC, Las Vegas, NV

YUCCA MOUNTAIN PROJECT OFFICE

QUALITY ASSURANCE SURVEILLANCE REPORT

OF

LOS ALAMOS NATIONAL LABORATORY

CONDUCTED - JULY 9-12, 1990

ACTIVITIES SURVEILLED:

QUALITY ASSURANCE REVIEW OF THE IMPLEMENTATION OF LOS ALAMOS NATIONAL LABORATORY YUCCA MOUNTAIN PROJECT PROCEDURES. VERIFICATION OF CORRECTIVE ACTION FOR YUCCA MOUNTAIN PROJECT OFFICE STANDARD DEFICIENCY REPORTS.

Prepared By: Charles C. Warren Date: 8-2-90
Charles C. Warren
Senior Quality Assurance Specialist

Approved By: Donald G. Horton Date: 8-6-90
for Donald G. Horton, Director
Quality Assurance
Yucca Mountain Project Office

1.0 EXECUTIVE SUMMARY

This surveillance by the Yucca Mountain Project Office (Project Office) Quality Assurance (QA) Division, which was conducted at Los Alamos National Laboratory (LANL), Los Alamos, New Mexico, indicated adequate implementation of the QA Program for those areas examined, with exception of the area of Corrective Action, which resulted in issuance of one Standard Deficiency Report (SDR). The SDR issued is included in Enclosure 1 of this report. In addition, as a result of concerns identified during the surveillance, a Deficiency Report (DR) was issued by LANL to document inadequate training of personnel in Procedure Change Requests.

2.0 INTRODUCTION

This report contains the results of Project Office QA Surveillance YMP-SR-90-32 of LANL, conducted at Los Alamos, New Mexico on July 9-12, 1990.

3.0 PURPOSE AND SCOPE

The purpose of this surveillance was to: 1) evaluate LANL compliance to internal procedures that had not been fully implemented at the time of Project Office QA Audit 90-01, and 2) to verify implementation of corrective action identified in accepted responses to Project Office SDRs that have reached or are past effective dates.

The following LANL procedures were reviewed for implementation to stated requirements:

Procedure	Title
TWS-QAS-QP-02.7, R0	PERSONNEL TRAINING
TWS-QAS-QP-05.1, R3	PREPARATION OF QUALITY ADMINISTRATIVE PROCEDURES
TWS-QAS-QP-15.2, R1	DEFICIENCY REPORTING
TWS-QAS-QP-17.3, R0	PROCEDURE FOR LANL YMP RECORDS MANAGEMENT
TWS-QAS-QP-18.1, R3	AUDITS
TWS-QAS-QP-18.2, R2	SURVEYS
TWS-QAS-QP-18.3, R2	AUDITOR QUALIFICATION AND CERTIFICATION

NOTE: During the surveillance it was determined that insufficient activity had occurred in the area of Document Control to warrant evaluation. Therefore, surveillance of implementation of Document Control Procedure TWS-QAS-QP-6.1 was not performed.

4.0 SURVEILLANCE PERSONNEL

The surveillance was performed by the following personnel:

C. C. Warren, Senior QA Specialist, MACTEC, Las Vegas, Nevada
R. B. Constable, General Engineer, DOE, Las Vegas, Nevada
A. I. Arceo, QA Engineer, SAIC, Las Vegas, Nevada

5.0 SUMMARY OF SURVEILLANCE RESULTS

Evaluation of activities for compliance to LANL Quality Procedures (QPs) was performed in accordance with checklists prepared by surveillance personnel. Specific QPs evaluated are those listed in Section 3.0. With exception of the area of corrective action, which is documented on SDR 562, implementation of procedures in the areas examined was determined to be adequate. However, a concern in the area of training to Procedure Change Requests (CRs) was identified to LANL during the surveillance. LANL DR No. 0051 was issued to address this concern and identify an inadequacy in training personnel to CRs.

A review of LANL SDR status indicated that six SDRs would be ready for verification of approved corrective action. However, preliminary discussions with the LANL Quality Assurance Project Leader (QAPL) indicated that two of these six SDRs (Nos. 466 & 511) were not ready for verification although both were past approved effective dates. An amended response requesting new effective dates was prepared for these SDRs and immediately forwarded to the Project Office for review and approval.

Verification of approved corrective action was performed for the four remaining SDRs (Nos. 468, 490, 491 & 513). Verification activities for these SDRs indicated that corrective action had not been completed as specified for Nos. 468, 490 or 513. YMPO SDR 562 was issued to LANL to identify untimely corrective action that resulted from not implementing approved responses by the specified effective dates for three of four SDRs reviewed. This SDR also identifies untimely corrective action for LANL Deficiency Reports 009 and 010, which were also past their effective dates without corrective action being completed.

During verification activities, it was determined that corrective action for SDR 491 was satisfactory and could be closed.

6.0 PERSONNEL CONTACTED

The following LANL personnel and Los Alamos Technical Associates (LATA) personnel were interviewed during the surveillance:

H. Nunes, QA Project Leader, LANL
J. Day, Verification Coordinator, LATA
D. Simundson, Training Coordinator, LATA
G. Gainer, Quality Assurance Staff (QAS), LATA
E. Gutierrez, QAS, LATA
P. Chavez, QAS, LATA
L. Schempp, Program Development Coordinator, LANL

7.0 SYNOPSIS OF SDRs

The following SDR was issued:

SDR No. 562, Rev.0

Corrective action for YMPO SDRs 468, 490 and 513 has not been completed by LANL although these SDRs are at or past their effective dates. Corrective action for LANL Deficiency Reports (DRs) 009 and 010 has not been completed although these DRs are past their effective dates.

8.0 RECOMMENDATIONS

None.

9.0 REQUIRED ACTIONS

A written response is required to the SDR included in Enclosure 1 of this report.

ENCLOSURE 1 (Attached)

SDR 562.

ENCLOSURE 1

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YMPO STANDARD DEFICIENCY REPORT

N-QA-038
4/89

Completed by Originating QA Organization

1 Date 07/11/90 | 2 Severity Level ☐ 1 ☒ 2 ☐ 3 | Page 1 of 2

3 Discovered During: YMP-SR-90-32

3a Identified By: C. C. Warren

4 SDR No. 562 Rev. 0

5 Organization: LANL

6 Person(s) Contacted: H. Nunes

7 Response Due Date is 20 Working Days from Date of Transmittal

8 Requirement (Audit Checklist Reference, if Applicable)
LANL YMP QAPP, Rev. 4.4, states the following regarding corrective action in Section 16.3:

9 Deficiency
Contrary to the above requirements, corrective action identified in the accepted responses to three SDRs (Nos. 468, 490, and 513), which were at or past specified effective dates, was not complete although these SDRs were

10 Recommended Action(s): ☒ Remedial ☐ Investigative ☒ Corrective
Identify remedial actions to be taken to correct the deficiencies noted in Block 9. Identify the cause of the condition and planned action to

Aprvl.

11 QAE/Lead Auditor/Date: C C Warren / 7-18-90

12 Division Manager/Date: N/A

13 Project Quality Mgr./Date: [signature]

Completed by Organization in Block 5

14 Remedial/Investigative Action(s)

15 Effective Date _____

16 Cause of the Condition & Corrective Action to Prevent Recurrence

17 Effective Date _____

18 Signature/Date

Comp. by Orig. QA Org.

19 Response Accepted	QAE/Lead Auditor/Date	Division Manager/Date	Project Quality Mgr./Date
20 Corrective Action Verif. Satisfactory	QAE/Lead Auditor/Date	Division Manager/Date	Project Quality Mgr./Date

21 Remarks

22 QA CLOSURE	QAE/Lead Auditor/Date	Division Manager/Date	PQM/Date

8 Requirement (continued)

Follow-up action shall be taken by the QA organization to verify proper implementation of the corrective action, to document its acceptance, and close-out the action. The organization responsible for implementing the corrective action shall ensure that the corrective action is completed in a timely manner.

9 Deficiency (continued)

presented to the Project Office Surveillance Team for verification of corrective action.

Corrective action for Los Alamos Deficiency Reports LANL-009 and LANL-010 was not completed although both are beyond the specified effective date of 6/29/90.

10 Recommended Actions (continued)

prevent recurrence.

Department of Energy
Yucca Mountain Project Office
P. O. Box 98608
Las Vegas, NV 89193-8608

WBS 1.2.9.3
QA

OCT 25 1990

Richard J. Herbst
Technical Project Officer
for Yucca Mountain Project
Los Alamos National Laboratory
University of California
N-5, Mail Stop J521
P.O. Box 1663
Los Alamos, NM 87545

ISSUANCE OF SURVEILLANCE REPORT YMP-SR-91-002 RESULTING FROM YUCCA MOUNTAIN PROJECT OFFICE (PROJECT OFFICE) QUALITY ASSURANCE (QA) SURVEILLANCE OF THE LOS ALAMOS NATIONAL LABORATORY

Enclosed is the report of QA Surveillance YMP-SR-91-002 conducted by Project Office QA at the Project Office, October 9-12, 1990.

One Standard Deficiency Report was issued. An information copy is enclosed.

If you have any questions, please contact either James Blaylock at (702) 794-7913 or FTS 544-7913 or Kenneth T. McFall at (702) 794-7190 or FTS 544-7190 of the Yucca Mountain Project QA staff.

for Donald G. Horton, Director
Quality Assurance
Yucca Mountain Project Office

QA:JB-506

Enclosures:
1. Surveillance Report YMP-SR-91-002
2. SDR 597

cc w/encls:
D. G. Horton, HQ (RW-3) FORS
J. W. Gilray, NRC, Las Vegas, NV
K. R. Hooks, NRC, Washington, DC
R. R. Loux, NWPO, Carson City, NV
S. W. Zimmerman, NWPO, Carson City, NV
E. V. Tiesenhausen, Clark County, Las Vegas, NV
Steve Bradhurst, Nye County, NV
M. J. Regenda, FSN, Las Vegas, NV
C. O. Wright, H&N, Las Vegas, NV
H. P. Nunes, LANL, Los Alamos, NM
D. W. Short, LLNL, Livermore, CA
M. A. Fox, REECo, Las Vegas, NV
R. R. Richards, SNL, 6310, Albuquerque, NM
N. J. Brogan, SAIC, Las Vegas, NV, 517/T-08
D. H. Appel, USGS, Denver, CO

OCT 25 1990

bcc w/encls:
J. H. Rusk, MACTEC, Las Vegas, NV
D. J. Harris, Harza, Las Vegas, NV, 517/T-06
J. B. Harper, SAIC, Las Vegas, NV, 517/T-38
K. T. McFall, SAIC, Las Vegas, NV, 517/T-06
C. H. Prater, SAIC, Las Vegas, NV, 517/T-06
James Blaylock, YMP, NV
R. B. Constable, YMP, NV

bcc w/o encls:
M. B. Blanchard, YMP, NV
W. R. Dixon, YMP, NV
V. F. Iorii, YMP, NV
E. H. Petrie, YMP, NV
E. L. Wilmot, YMP, NV
W. A. Wilson, YMP, NV

YUCCA MOUNTAIN PROJECT OFFICE

QUALITY ASSURANCE SURVEILLANCE REPORT OF

LOS ALAMOS NATIONAL LABORATORY

SURVEILLANCE REPORT NUMBER YMP-SR-91-02

CONDUCTED OCTOBER 9 THROUGH OCTOBER 11, 1990

ACTIVITIES SURVEILLED:

PROCUREMENT, CALIBRATION OF MEASURING AND TEST EQUIPMENT, DEFICIENCY REPORTING AND CORRECTIVE ACTION

Prepared by: Kenneth T McFall Date: 10/22/90
Kenneth T. McFall
Quality Assurance Scientist (Lead)

Prepared by: Donald J Harris Date: 10/22/90
Donald J. Harris
Quality Assurance Engineer

Approved by: Robert B Constable Date: 10/22/90
Robert B. Constable
DOE (Lead)

Approved by: James Blaylock for Date: 10/24/90
Donald G. Horton, Director
Quality Assurance
Yucca Mountain Project Office

ENCLOSURE 1

1.0 INTRODUCTION

This report contains the results of Yucca Mountain Project Office (Project Office) Quality Assurance (QA) surveillance of Los Alamos National Laboratory, YMP-SR-91-02, conducted in Los Alamos, New Mexico to verify compliance and implementation of their approved procedures.

2.0 PURPOSE AND SCOPE

The purpose of this surveillance was to determine the adequacy and effectiveness of the implementation of selected LANL QA Procedures. The scope of the surveillance covered the procedures and activities associated with the following criteria:

IV Procurement
XII Control of Measuring and Test Equipment
XV Nonconformances
XVI Corrective Action

Criterion XV, (Nonconformances) and XVI, (Corrective Action) are combined by LANL into a single procedure, "Deficiency Reporting". The follcwing LANL implementing procedures were examined during the course of the surveillance:

1. TWS-QAS-QP-04.1, Revision 2, Procedure for Procurement

2. TWS-QAS-QP-04.2, Revision 2, Procedure for Accepting the Performance of Procured Services

3. TWS-QAS-QP-04.3, Revision 1, Qualification of Suppliers of Engineered Items and Services

4. TWS-QAS-QP-12.1, Revision 4, Procedure for Control of Measuring and Test Equipment

5. TWS-QAS-QP-15.2, Revision 1, Deficiency Reporting

6. TWS-QAS-QP-16.2. Revision 0, Procedure for Trending

In addition to the above procedures, the surveillance included the attempt to verify the corrective action and closure of all Standard Deficiency Reports (SDRs) identified by LANL as ready for closure.

3.0 SURVEILLANCE PERSONNEL

The surveillance was conducted by the following personnel:

K. T. McFall, QA Scientist, SAIC/Project Office, Surveillance Lead
D. J. Harris, Sr. QA Engineer, Harza Engineering/Project Office, Team Member
R. B. Constable, YMPO Project Office, DOE Lead
S. W. Zimmerman, State of Nevada, Observer

4.0 SUMMARY OF SURVEILLANCE RESULTS

The documents listed in Section 2.0 of this report were the source of questions used to conduct this surveillance. Checklists generated from these documents were used to determine compliance. The following results were obtained during the surveillance:

TWS-QAS-QP0-04.1, Rev. 2, Procedure for Procurement

A total of twelve Purchase Order procurement packages were examined for compliance with the requirements stated in this procedure. Overall the procurement packages involving this procedure were found to be in good order with only a few minor document omissions which were corrected during the course of the surveillance.

TWS-QAS-QP-04.2, Rev. 2, Procedure for Accepting the Performance of Procured Services

In examining implementation of this procedure it was noted that the existing contracts predate the procedure by a considerable time, thus negating many of the requirements that would be called for in a contract that would be let after the effective date of this procedure. In the areas that were surveilled no problems were encountered with the exception of the Hydro Geo Chem Inc. contract which was missing the annually required "Acceptance of Results of Procured Services" form. This condition had been noted by internal LANL review and documented by the issuance of LANL Deficiency Reports (DRs) 0083 and 0084, dated August 16, 1990.

TWS-QAS-QP-04.3, REV. 1, Qualification of Suppliers of Engineered Items and Services

There were only three suppliers on the Authorized Vendors List (AVL) which could be examined during this surveillance. There were no problem areas identified with the implementation of this procedure.

TWS-QAS-QP-12.1, Rev. 4, Procedure for Control of Measuring and Test Equipment

Calibration of measuring and test equipment was reviewed on a limited basis with no intent of examining all all equipment involved in the Project. The examination centered on balances. M&TE Calibration Records which had exhibited some problems in the past were reviewed and found to be up to date and complete, primarily as a result of recent corrective action resulting from Project Office SDRs generated from surveillance YMP-SR-90-018. The instrumentation examined all had the required Calibration Labels containing all called for information. No problem areas were encountered in the implementation of this procedure.

TWS-QAS-QP-15.2, Rev. 1, Deficiency Reporting

A sample of 19 Deficiency Reports (DRs) from a population of 109 was reviewed to determine if the DRs were being processed in accordance with the procedure. For those DRs processed through any given procedure step,the DRs reflected an acceptable process. However, the review indicated numerous DRs currently have not been dispositioned within the allotted procedure time frame and the assigned dispositioner failed to request an extension. In addition, the QA organization failed to perform the verification for closure of the DR within the allotted time frame specified by the procedure.

The Project Office initiated SDR 562 during Surveillance YMP-SR-90-32 (7/11/90), which identified recurring problems in effective and timely implementation of LANL's corrective action system. LANL's QA organization has committed to amend their response to SDR 562 to encompass their Deficiency Reports with a corrective action completion date of November 15, 1990.

In LANL's initial response to SDR 562, they committed and have assigned Mr. Rich Morley, a QA Liaison person to head up LANL's deficiency reporting system. Mr. Morley has been provided full authority to direct needed actions. Mr. Morley has developed a computer tracking system for the DRs and Project Office Deficiency Documents. The following documents are generated:

- o Deficiency Report Log
- o Overdue Response Report
- o Overdue Completion Report
- o Overdue Verification Report

Mr. Morley has also initiated weekly meetings with the QA Liaison personnel assigned to each LANL organization to discuss their deficiency documents and status. Based on the above LANL action an improvement should be forth-coming in regards to LANL's deficiency reporting system.

TWS-QAS-QP-16.2, Rev. 0, Procedure for Trending

The LANL Trend Analysis Report for the period of January 1, through January 30, 1990 was evaluated for compliance to the procedure. The evaluation resulted in the initiation of SDR 597 for procedure noncompliance. The Trend Report failed to address Nonconformance Reports (NCRs) generated per superseded QP-15.1 and Corrective Action Reports (CARs) generated per superseded QP-16.1 during the period from 1 January through 3 April, 1990. The Trend Report also failed to address deficiencies remaining open at the end of the last 12 months and provide a comparison of the present 6 months trend to the previous 6 months. In addition, DRs were not issued for the positive trends in Criteria IV, V, and VII, nor was there any objective evidence of management action for trend indication in Criterion VI.

During the course of the surveillance, verification of corrective action was performed on 6 SDRs issued by the Yucca Mountain Project Office against LANL. The specific SDRs were: 464, 465, 490, 491, 512, and 513. The Completion of Corrective Action Date for SDR 466 was extended to 12/16/90, SDR 511 was extended to 11/30/90, and SDR 515 was extended to 12/15/90. An amended response to SDR 562 will be forthcoming.

5.0 PERSONS CONTACTED DURING THE SURVEILLANCE

H. Nunes, QAPL, LANL
G. Rand, QA Engineer, LATA
J. Day, QA Verification Coordinator, LATA
G. Gainer, QA Engineer, LATA
R. Morley, QA Liaison, LANL
T. Morgan, QA Liaison, LANL
M. Clevenger, QA Liaison, LANL
G. Cort, Deputy QA Project Leader, LANL

6.0 MEASURING AND TEST EQUIPMENT USED DURING THE SURVEILLANCE

There was no measuring and/or test equipment used during the course of this surveillance.

7.0 SYNOPSIS OF DEFICIENCY DOCUMENTS

SDR 597; Trend Report failed to address certain Nonconformance Reports and certain open deficiencies. Deficiency Reports were not issued for positive trends as required.

8.0 RECOMMENDATIONS

The Project Office QA Surveillance Team recommends that LANL apply additional resources to the corrective action system until the status of each deficiency document is current with required time frame specified in the procedure.

9.0 REQUIRED ACTIONS

LANL is requested to provide a response to SDR 597 within 20 working days of the transmittal of the Standard Deficiency Report. In addition, LANL is requested to provide a request for extension of the due date for implementation of corrective action on SDRs 466, 511, and 515.

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YMPO STANDARD DEFICIENCY REPORT

N-QA-038
4/89

Page 1 of 2

Completed by Originating QA Organization

1 Date 10/10/90

2 Severity Level ☐ 1 ☒ 2 ☐ 3

3 Discovered During YMP-SR-91-002

3a Identified By D. J. Harris

4 SDR No. 597 Rev. 0

5 Organization LANL

6 Person(s) Contacted Rich Morley/J.L. Day

7 Response Due Date is 20 Working Days from Date of Transmittal

8 Requirement (Audit Checklist Reference, if Applicable)
QP 16.2, Revision 0, Change Request 120 and 123, Procedure for Trending.

1. Paragraph 6.1-1 states in part, "Evaluates DRs and SDRs that have been

9 Deficiency
1. Trend Report only references NCRs that were not closed and transferred to DRs as of 3/26/90. The report has no objective evidence that NCRs processed and closed in accordance with QP 15.1 were included in the

10 Recommended Action(s): ☒ Remedial ☐ Investigative ☒ Corrective

Identify the remedial action to be taken to correct the deficiencies noted in Block 9 and identify the cause of the condition and the planned action to

Aprvl.

11 QAE/Lead Auditor/Date D. Harris 10-15-90

12 Division Manager/Date N/A

13 Project Quality Mgr./Date [signature]

Completed by Organization in Block 5

14 Remedial/Investigative Action(s)

15 Effective Date _____

16 Cause of the Condition & Corrective Action to Prevent Recurrence

17 Effective Date _____

18 Signature/Date

Comp. by Orig. QA Org.

19 Response Accepted	QAE/Lead Auditor/Date	Division Manager/Date	Project Quality Mgr./Date
20 Corrective Action Verif. Satisfactory	QAE/Lead Auditor/Date	Division Manager/Date	Project Quality Mgr./Date

21 Remarks

22 QA CLOSURE	QAE/Lead Auditor/Date	Division Manager/Date	PQM/Date

ENCLOSURE 2

ENCLOSURE

ORIGINAL
THIS IS A RED STAMP

YMPO STANDARD DEFICIENCY REPORT
CONTINUATION SHEET

N-QA-038
2/89

SDR No. 597 Page 2 of 2

8 Requirement (continued)

issued through QP 15.2 (effective 3/12/90) (prior to 3/12/90, NCR issued through QP 15.1)."

2. Paragraph 6.1-4 states in part, "Provides the following information: Number of deficiencies remaining open at the end of each of the last 12 months."

3. Paragraph 6.1-4 states in part, "Provides the following information: A comparison of the present six months period trend to the previous quarter's annual trend".

4. Paragraph 6.3-2 states in part, "Issues DRs based on the Trend Report as warranted. DR issued by this process will be tracked, verified, and closed using QP 15.2."

5. Paragraph 6.3-3 states in part, "Initiates management action for those items that may not require a corrective action but may warrant further assessment."

9 Deficiency (continued)

Trend Report.

2. The Trend Report for period ending 6/30/90 fails to address the number of deficiencies remaining open at the end of the last 12 months.

3. The Trend Report fails to provide a comparison of the present six months trend to the previous 6 months trend. The report only reflects the current trend period.

4. DRs were not issued for the positive trend indicated in the January/December 1989 or January/June 1990 Trend Report.

5. Further assessments were not addressed in the current Trend Report. The report indicated Criteria 4, 5, and 17 as positive trends. The report reflects indication of a positive trend in Criteria 6 but no further action was addressed.

10 Recommended Actions (continued)

prevent recurrence.

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
QUALITY ASSURANCE ADMINISTRATIVE PROCEDURE

Title: CORRECTIVE ACTION REQUESTS			
Procedure No.: QAAP 16.1	Revision: 3	Date: 10/29/90	Page 1 of 16
Concurrence: [signature] Date: 10/17/90		Approval: [signature] Date: 10/17/90	

1.0 PURPOSE

The purpose of this procedure is to identify requirements and prescribe responsibilities and methods to ensure that conditions adverse to quality and significant conditions adverse to quality are promptly identified and corrected.

2.0 SCOPE

This procedure is applicable to programmatic deficiencies and repetitive deficient conditions. Hardware related deficiencies are identified and controlled in accordance with QMP-15-01, *Control of Nonconformances*; however, significant hardware-related deficiencies shall also be processed in accordance with this procedure. This procedure shall be used by Office of Civilian Radioactive Wastes Management (OCRWM) and direct-support contractor personnel for evaluating and correcting deficiencies identified within or by the OCRWM and direct-support contractor organizations.

3.0 REFERENCES AND DEFINITIONS

3.1 REFERENCES

3.1.1 *Quality Assurance Requirements Document* (QARD), DOE/RW-0214

3.1.2 *Quality Assurance Program Description Document* (QAPD), DOE/RW-0215

3.2 DEFINITIONS

The definitions of standard terms may be found in the Glossary contained in reference 3.1.1 or in the Program Glossary.

3.2.1 QA Representative: The QA Representative (QAR) is an individual representing the OCRWM QA office.

3.2.2 Severity Level 1: Severity level 1 is assigned to CARs which document significant conditions adverse to quality. These deficiencies require remedial action to correct the deficiency, investigative action to determine extent and root cause, and corrective action to prevent recurrence.

3.2.3 Severity Level 2: Severity Level 2 is assigned to CARs which require remedial and corrective action to prevent recurrence, and possibly investigative actions to determine the extent of the deficiency, but does not exhibit the severe attributes of a Level 1 deficiency.

3.2.4 Severity Level 3: Severity Level 3 is characterized by a minor deficiency requiring only remedial action. These deficiencies are generally isolated in nature or have a very limited scope. In addition, the integrity of the end result of the activity is not affected, nor does the deficiency affect the ability to achieve those results.

4.0 RESPONSIBILITIES

4.1 DIRECTOR, OFFICE OF QUALITY ASSURANCE (OQA)

The Director, OQA, is responsible for:

4.1.1 Approving the resolution and closure of Corrective Action Requests which pertain to OQA.

4.1.2 Preparing and maintaining this QAAP.

4.2 OCRWM MANAGERS

OCRWM Managers (i.e., the Cognizant Branch Chief, Division Director, Associate or Office Director, or Director, OCRWM) or their designees, are responsible for:

4.2.1 Controlling activities and/or the use of products identified as deficient until resolution is reached;

4.2.2 Taking immediate action to correct deficiencies where threat of degradation or irretrievable loss to the OCRWM Program exists;

4.2.3 Taking remedial action to correct identified deficiencies;

4.2.4 Investigating deficiencies to determine the overall extent of the problem and root cause; and

4.2.5 Implementing measures to prevent recurrence of deficiencies

4.3 OCRWM PERSONNEL

OCRWM personnel (including Direct-Support Personnel) are responsible for:

4.3.1 Identifying and reporting deficiencies observed in the conduct of Program activities or in the characteristics of Program products

4.3.2 Initiating a Corrective Action Request (CAR) as necessary; and

4.3.3 Providing support in resolving deficiencies.

4.4 DIVISION DIRECTORS, OFFICE OF QUALITY ASSURANCE

The Division Directors, HQQAD and YMQAD are responsible for:

4.4.1 The overall implementation of this procedure.

4.4.2 Reviewing and approving the issuance and closure of Corrective Action Requests (CARs).

4.5 QUALITY ASSURANCE REPRESENTATIVE (QAR)

The QAR is responsible for:

4.5.1 Initiating a CAR when an adverse condition or a significant adverse condition to quality is identified.

4.5.2 Reviewing the response and verifying and documenting implementation of corrective actions.

4.6 CAR COORDINATOR

The CAR Coordinator is responsible for:

4.6.1 Assigning unique CAR numbers to approved CARs.

4.6.2 Tracking the status of CARs.

4.6.3 Transmitting closed CARs to the Local Records Center (LRC).

4.6.4 Issuing periodic status reports of open CARs

5.0 GENERAL

5.1 OCRWM personnel and contractor support personnel shall initiate a CAR, as applicable, in accordance with this procedure.

5.2 Conditions that warrant a stop work shall be controlled in accordance with QAAP 16.2, *Stop Work Authority* or QMP-01-02, *Stop Work*.

5.3 Conditions reported by Corrective Action Requests are trended in accordance with QAAP 2.9, *Quality Assurance Program Status and Trend Reporting*.

5.4 Corrective Action Requests shall be assigned a Severity Level based on the criteria in 5.4.1 through 5.4.3.

5.4.1 Severity Level 1 - The CAR reports deficiencies that involve one or more of the following conditions:

a. Significant damage to natural barriers, structures, systems, or components which will require extensive evaluation, extensive redesign, or extensive repair in order to assure public health and safety;

b. Loss of essential data or information needed for licensing;

c. Significant deficiencies in design, construction, testing, or performance assessment that were detected subsequent to formal verification and acceptance;

d. A significant deficiency in design as approved for construction such that the design deviates extensively from design criteria and bases;

e. A significant deviation from performance objectives or specification which will require extensive evaluation, extensive redesign or extensive repair to establish the adequacy of a natural barrier, structure, system or component to meet design criteria and bases;

f. A significant error detected in a computer program after it has been related for use; or

g. Significant deficiencies such as a breakdown in a participant QA program (e.g., failure of an organization to establish and implement appropriate QA and technical requirements, plans, and procedures) and/or repetitive programmatic and hardware deficiencies for which previous corrective action has not been reasonable prompt or effective.

5.4.2 Severity Level 2 - The CAR reports deficiencies that do not fall under the criteria in 5.4.1 but involve one or more of the following conditions:

a. Operating outside the scope of the Quality Assurance Program or approved quality assurance procedures where both remedial and investigative corrective actions are required; or

b. Repetitive hardware deficiencies for which no previous corrective action measures were performed or were ineffective.

5.4.3 Severity Level 3 - The CAR reports deficiencies that do not fall under the criteria in 5.4.1 or 5.4.2 and meet one or both of the following conditions:

a. The integrity of the end results of the activity is not affected nor does the deficiency affect the ability to achieve those results; or

b. The deficient condition is an isolated occurrence or very limited in scope.

5.5 Disputes that arise during the performance of this procedure shall be brought to the attention of appropriate management and, if not resolved, shall be elevated progressively to higher levels of management and, if necessary, to the Director, OCRWM.

6.0 PROCEDURE

6.1 INITIATION AND ISSUANCE

6.1.1 Upon discovering an apparent deficiency, OCRWM personnel shall initiate a CAR by completing the initiator actions (items 1 through 8) in accordance with Attachment I when one or more of the following occurs:

a. A potential condition adverse to quality is identified; or

b. Upon the identification of an adverse trend (refer to QAAP 2.9, *Quality Assurance Program Status and Trend Reporting*).

NOTE: Use the CAR Continuation Sheet, Attachment II, as needed.

6.1.2 The initiator shall forward the CAR to the HQ or YMP QA Division Director, as applicable.

6.1.3 The QADD shall evaluate the CAR for the validity of the identified condition. If the CAR is not valid, the QADD shall document the justification on the CAR, return it to the initiator, and retain a copy in OQA files.

6.1.4 The QADD shall review the CAR to determine if the condition warrants a stop work. If the condition warrants a stop work, recommend a Stop Work Order/Request in accordance with QAAP 16.2, *Stop Work Authority* or QMP-01-02, *Stop Work*.

6.1.5 The QADD shall initiate and process a QA Trend Data Report in accordance with QAAP 2.9.

6.1.6 The QADD or designee shall identify, on the CAR, the responsible organization for corrective action, response due date, and severity level.

6.1.7 The QADD shall sign and date the CAR, obtain a CAR number from the CAR Coordinator, and enter the number on the CAR.

6.1.8 The CAR Coordinator shall maintain a CAR log (may be a computer data base) for issuing unique numbers and for tracking the process and status of the CAR. Assign a number to the CAR as follows and enter in the log.

XX - YY - NNN

where:

XX = Acronym for the QA division issuing the CAR (i.e., HQ - Headquarters, YM - Yucca Mountain.

YY = the last two digits of the fiscal year that the CAR is initiated.

NNN = the next unique sequential number for the applicable fiscal year (each new year begins with 001).

6.1.9 The QADD shall forward a copy of the CAR, by memorandum or letter, to the responsible organization's management for response. The letter shall identify the actions required and the response due date.

6.1.10 The QADD shall forward the original copy of the CAR to the CAR Coordinator with a copy of above transmittal memorandum or letter.

6.1.11 Throughout the remaining process below, the QADD and QAR shall ensure that the CAR Coordinator is notified of all CAR status changes and is provided copies of all correspondence relative to the CAR.

6.1.12 The CAR Coordinator shall update the log as changes occur and reference, in the "Verification" section on the CAR, all relevant correspondence associated with the CAR.

6.2 CORRECTIVE ACTION RESPONSE

6.2.1 The manager assigned responsibility for response to a CAR shall develop a corrective action response and submit, on a CAR Continuation Sheet, to the appropriate OQA Division Director (QADD) for evaluation and acceptance. See Attachment III for preferred format for documenting CAR responses on the CAR Continuation Sheet.

6.2.2 The responsible manager shall submit a written request for an extension if it becomes apparent that the requested response due date cannot be met.

6.2.3 Upon receipt of a request for extension of the response due date, the QADD shall evaluate the extension request for approval or disapproval and issue a letter to the responsible organization and CAR Coordinator notifying them of the results of the evaluation.

6.3 RESPONSE EVALUATION

6.3.1 Upon receipt of a response from the responsible organization, the QAR shall evaluate the response to ensure that it addresses the required elements and that the proposed actions will sufficiently resolve the adverse condition. The QAR shall provide the evaluation results and recommendations to the Director, OQA or respective OQA Division Director. The Director, OQA shall approve the corrective action responses for CARs where OQA is responsible for the corrective action.

6.3.2 If the response is acceptable, the Director, OQA or respective OQA Division Director shall sign and date the response for OQA acceptance and issue a letter to the responsible organization notifying them of the accepted response. If the response is unacceptable, the Director, OQA or respective OQA Division Director shall issue a letter to the responsible organization requesting an amended response.

6.3.3 The responsible manager shall notify OQA if the corrective actions in a previously submitted CAR response needs to be changed and submit an amended response, if requested by OQA, in accordance with 6.2.1.

6.3.4 Amended responses to CARs shall be reviewed and processed in accordance with paragraphs 6.3.1 and 6.3.2.

6.3.5 The QAR shall forward the original copy of signed and accepted responses to the CAR Coordinator. The CAR Coordinator shall ensure that the accepted response is attached to the CAR and correctly paginated.

6.4 OVERDUE RESPONSES

6.4.1 The CAR Coordinator shall periodically review the CAR log and identify those CARs that have not been responded to by the response due date (if a receipt for extension has been received, the CAR is not considered overdue). Notify the OQA Division Director for resolution.

6.4.2 Should violations of established due dates persist or if unsatisfactory responses continue, the Director, OQA, shall take whatever management action is necessary to obtain satisfactory results from the responsible party.

6.5 VERIFICATION OF CORRECTIVE ACTION

6.5.1 The CAR Coordinator shall periodically review the CAR log and identify the CARs that are ready for verification based on their corrective action due dates, and notify the designated QAR.

6.5.2 The QAR shall verify that the proposed corrective/preventive actions have been satisfactorily implemented. If the implementation is found to be complete and acceptable, the QAR shall document the verification on the CAR identifying the objective evidence reviewed.

6.5.3 If the implementation is found unacceptable, or cannot be verified, the QAR shall initiate and issue a letter delineating specific details of the corrective action found to be unsatisfactory, providing recommendations for corrections, and requesting a new response and implementation date. The QAR shall notify the CAR Coordinator of revised status.

6.5.4 Process revised responses and/or revised dates for completion of implementation in accordance with subsections 6.2 and 6.3.

6.5.5 The QAR shall ensure that all documents that are to remain with the CAR are paginated and identified with the CAR number. The QAR shall sign and date the CAR and forward the CAR package to the QADD for further processing in accordance with step 6.6.

6.6 CAR CLOSURE

6.6.1 Upon receipt of a CAR that has been verified and the implementation found acceptable, the QADD shall review the CAR for procedural compliance.

6.6.2 If the CAR is not ready for closure, the QADD shall return it to the responsible QAR for the necessary corrections.

6.6.3 When the CAR is acceptable and ready for closure, the Director, OQA or QADD shall sign and date the CAR and forward to the CAR Coordinator. The Director, OQA or QADD shall issue a letter to the responsible organization notifying them that the CAR is closed. The Director, OQA shall approve the closure of CARs for which OQA was the responsible organization.

6.6.4 The CAR Coordinator shall update the CAR log and process the complete CAR package to the Local Records Center (LRC) in accordance with QMP-17-01, *Records Management: Record Source Requirements*.

6.7 VOIDING CARs

6.7.1 When it is determined that a CAR with an assigned number is potentially invalid, the cognizant OQA Division Director shall discuss the condition with the initiator and the QAR(s) who are involved with the CAR.

6.7.2 If it is agreed that the CAR is invalid, the QADD shall ensure that the complete justification is documented with signatures and dates of those involved in the decision and close the CAR in accordance with Section 6.5.

6.7.3 The voided CAR and any supporting documentation shall be maintained in accordance with QMP-17-01.

6.8 STATUS

6.8.1 The CAR Coordinator shall provide periodic status reports to the Director, OQA and the OQA Division Directors. The reports shall provide a status of all open OCRWM CARs.

7.0 RECORD

7.1 Open CARs shall be maintained by the designated CAR Coordinator. Closed CARs generated as a result of this procedure shall be assembled by the CAR Coordinator and processed to the LRC in accordance with QMP-17-01, *Records Management: Record Sources Requirements*. At a minimum, the following are considered QA Records:

7.1.1 CARs (including voided CARs),

7.1.2 CAR Continuation Sheets,

7.1.3 Relevant correspondence associated with the CAR.

8.0 ATTACHMENTS

8.1 ATTACHMENT I - Corrective Action Request

8.2 ATTACHMENT II - Corrective Action Request Continuation Sheet

8.3 ATTACHMENT III - Corrective Action Response Format

8.4 ATTACHMENT IV - QAAP 16.1 Flowchart

ATTACHMENT I

OFFICE OF CIVILIAN
RADIOACTIVE WASTE MANAGEMENT
U.S. DEPARTMENT OF ENERGY
WASHINGTON, D.C.

[14] CAR NO. _____
DATE: _____
SHEET: _____ OF _____
QA
WBS NO.: _____

CORRECTIVE ACTION REQUEST

[1] Controlling Document		[3] Related Report No.
[2] Responsible Organization	[4] Discussed With	
[10] Response Due	[11] Responsibility for Corrective Action	[12] Stop Work Order Y or N

[5] Requirement:

[6] Adverse Condition:

[7] Recommended Action(s):

[8] Initiator Date:	[9] Severity Level - 1 ☐ 2 ☐ 3 ☐	[13] Approved by Date: OQA _____

[16] Verification of Corrective Action:

[18] Corrective Action Completed and Accepted: QAR _____ Date _____	[17] Closure Approved By: OQA _____

ATTACHMENT I (cont'd)

INSTRUCTIONS FOR THE PREPARATION OF OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT CORRECTIVE ACTION REQUEST

Initiator

1. Enter the document and revision which has not been complied with.
2. Enter the number of the report for the activity that resulted in identifying the adverse condition (i.e., Audit Report No., Surveillance Report No.). Enter N/A if there is not a related report.
3. Enter the organization responsible for the adverse condition (e.g., USGS, RW-40).
4. Enter the name of the individual with whom the CAR condition was discussed.
5. State or paraphrase the requirement in narrative, concise form including specific reference (para./section no.) to the governing document (block 1).
6. Describe the adverse condition found, in concise narrative form including reference to examples discovered. (Use and refer to continuation sheet, if needed.)
7. Provide a recommended action that would be acceptable.
8. Enter your name and date.

Director, OQA (or designee)

9. Check appicable box.
10. Enter the date the response is due from the responsible organization.
11. Enter the individual (name and title) who is responsible for responding to the CAR.
12. Circle N if a Stop Work Order was not issues or Y if one was issued.
13. Sign and date the CAR.
14. Obtain from the CAR Coordinator the next sequential number from the CAR log and enter the date the CAR is issued.

QA Representative

15. Document the objective evidence used during verification.
16. Sign and date when corrective action is verified and accepted.

Director, OQA

17. Verify CAR is acceptable for procedural compliance; sign and date.

ATTACHMENT II

CAR NO. _____
DATE: _____
SHEET: _____ OF _____

OFFICE OF CIVILIAN
RADIOACTIVE WASTE MANAGEMENT
U.S. DEPARTMENT OF ENERGY
WASHINGTON, D.C.

CORRECTIVE ACTION REQUEST
(continuation sheet)

ATTACHMENT III

CAR NO. HQ-YY-NNN
DATE:
SHEET: ____ OF ____

OFFICE OF CIVILIAN
RADIOACTIVE WASTE MANAGEMENT
U.S. DEPARTMENT OF ENERGY
WASHINGTON, D.C.

CORRECTIVE ACTION REQUEST
(continuation sheet)

CORRECTIVE ACTION RESPONSE:

1. CORRECTIVE ACTION FOR DEFICIENT CONDITION #_____

   A. Extent of Deficiency: (required for Seventy Level 1 - also for Seventy Level 2 if requested by OQA)

   [Document investigative action and identify the extent of the deficient condition.]

   B. Root Cause: (required for Seventy Levels 1 & 2)

   [Determine and identify the root cause for the deficient condition.]

   C. Remedial Action: (action to correct the deficient condition - required for all CARs)

   [Provide concise statement of each specific remedial corrective action with name of responsible individual and scheduled completion date.]

   D. Corrective Action to Prevent Recurrence: (action taken to address the root cause and prevent recurrence of the deficient condition - required for Seventy Levels 1 & 2)

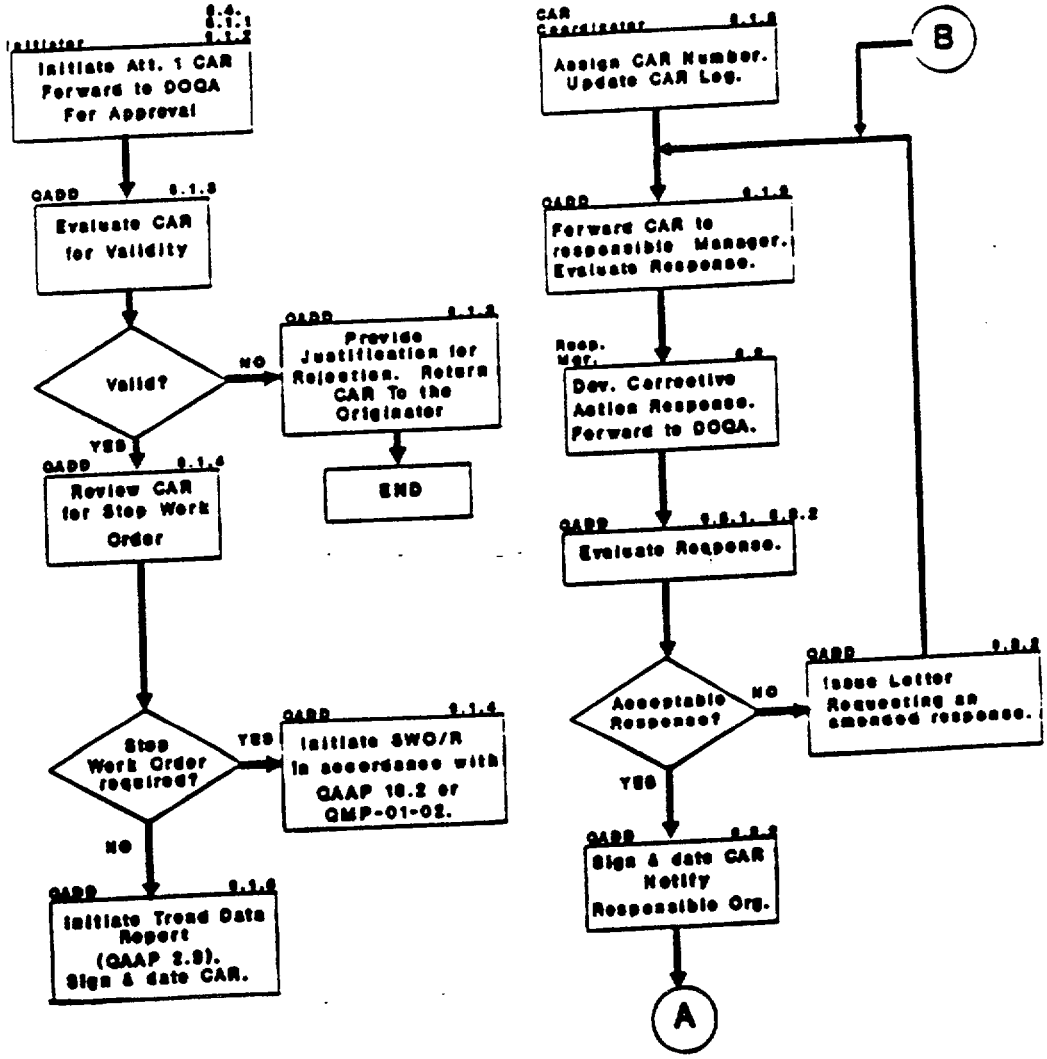
   [Provide concise statement of each specific action with name of responsible individual and scheduled completion date.]

2. [Repeat 1 above for each deficient condition.]

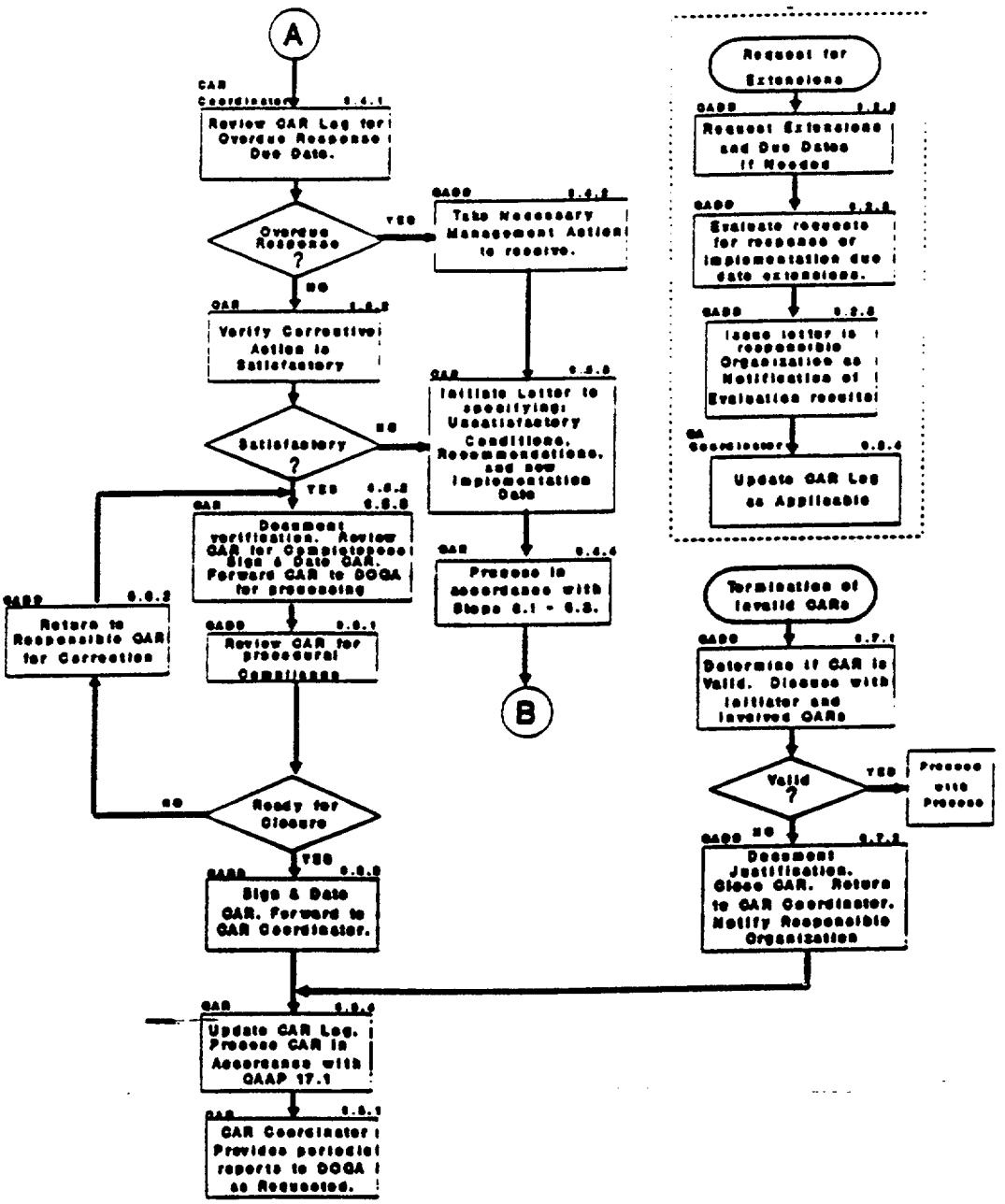
Response Approved:_____ _____
Responsible Manager Date

Response Accepted:_____ _____
OQA Date

ATTACHMENT IV



ATTACHMENT IV (cont'd)



CORRECTIVE ACTION REQUESTS

16.1, REV. 3

The following number is for OCRWM records management purposes only and should not be used when ordering this publication.

Accession No.: HQ0.901017.0001

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
QUALITY ASSURANCE ADMINISTRATIVE PROCEDURE

Title: AUDIT PROGRAM			
Procedure No.: QAAP 18.2	Revision: 3	Date: 1/3/91	Page 1 of 14
Concurrence: R.W. Cl for D.H.	Date: 12/28/90	Approval: R.W. Cl for D.H.	Date: 12/28/90

1.0 PURPOSE

This procedure establishes the responsibilities and methods for planning, conducting, and documenting the formal and comprehensive quality assurance (QA) audit program conducted by the Office of Civilian Radioactive Waste Management (OCRWM), Office of Quality Assurance (OQA).

2.0 SCOPE

This procedure applies to all OCRWM internal and external QA audits conducted by and for OCRWM. The requirements for audits of OCRWM suppliers are addressed in QAAP 7.1, *Control of Purchased Services* and *QMP-07-04, Supplier Evaluation/Qualified Suppliers List.*

3.0 REFERENCES AND DEFINITIONS

3.1 REFERENCES

3.1.1 *Quality Assurance Requirements Document* (QARD), DOE/RW-0214

3.1.2 *Quality Assurance Program Description* (QAPD), DOE/RW-0215

3.2 DEFINITIONS

3.2.1 The definitions of standard terms may be found in the Glossary contained in reference 3.1.1.

3.2.2 Audit Team Leader (ATL) - A lead auditor who organizes, performs, and directs an audit; reports conditions adverse to quality; and evaluates related corrective actions.

3.2.3 External Audit - OCRWM QA program audits of other affected organizations and suppliers to determine the status, adequacy, compliance to and effectiveness of the audited organization's QA program.

3.2.4 Internal Audit - Audits conducted by the OCRWM QA Organization to determine the status, adequacy, compliance to, and effectiveness of the OCRWM QA program. Internal audits of the OCRWM QA program are conducted, as a minimum, once each year or at least once during the life of the activity affecting quality, whichever is shorter.

4.0 RESPONSIBILITIES

4.1 ASSOCIATE AND OFFICE DIRECTORS, OCRWM

The Associate and Office Directors, OCRWM or designees are responsible for:

4.1.1 Providing technical staff as technical specialists to participate in selected audits.

4.1.2 Reviewing audit reports for information or responses.

4.2 DIRECTOR, OQA

The Director, OQA or designee is responsible for the development, implementation, and maintenance of the QA audit program including:

4.2.1 Preparing and maintaining this QAAP.

4.2.2 Scheduling of audits including supplemental audits.

4.2.3 Approving audit plans and issuing notification letters.

4.2.4 Assuring that Audit Team Leaders are properly trained, qualified, and certified.

4.2.5 Approving and issuing audit reports.

4.2.6 Assuring that related corrective actions responses are evaluated.

4.2.7 Assuring that audit record packages are prepared and submitted to the Quality Records Center.

4.3 AUDIT TEAM LEADER (ATL)

The Audit Team Leader is responsible for:

4.3.1 Planning and preparing for the audit activities.

4.3.2 Identifying audit team.

4.3.3 Developing audit plan and audit notification documents.

4.3.4 Assuring audit team is properly trained and qualified.

4.3.5 Assuring that audit team members are independent of direct responsibility for the activity being audited.

4.3.6 Orienting other audit team members

4.3.7 Approving audit plans and checklists.

4.3.8 Coordinating audit planning sessions, itineraries, and logistics.

4.3.9 Notifying auditee of problems requiring immediate attention.

4.4 AUDIT TEAM MEMBERS

Audit team members are responsible for:

4.4.1 Preparing audit checklists as assigned.

4.4.2 Attending meetings scheduled by the audit team leader.

4.4.3 Conducting portions of the audit as assigned.

4.4.4 Completing assigned portions of the audit checklist.

4.4.5 Preparing drafts of CARs/NCRs.

4.4.6 Writing portions of the audit report.

5.0 GENERAL

Audit activities are scheduled and planned to ensure that program-deliverable products and processes are evaluated commensurate with importance in achieving mission objectives and scheduled completion dates assigned to the products or processes. Audit results shall be analyzed by the audit team to determine overall QA program adequacy and effectiveness. Management at all levels within each affected organization shall be actively involved with the audit process.

6.0 PROCEDURE

6.1 SCHEDULING

6.1.1 The Director, OQA shall develop an audit schedule which identifies internal and external audits planned for the fiscal year.

Audits shall be scheduled to provide coverage and coordination with ongoing QA program requirements, and at a frequency commensurate with the status and importance of the

activity. Audits shall be initiated as early in the life of the activity as practical to assure effective controls are implemented during program or project activities and shall be conducted at intervals consistent with the schedule for completing the specific activity.

The audit schedule and scope of each audit shall be based on an evaluation by the Director, OQA, of the applicable and active QA program elements. These evaluations shall include an assessment of the effectiveness of the applicable and active elements of the QA program to be audited. The evaluation shall also consider results of previous surveillances; results of previous internal, external, and extrinsic audits (audits of an organization performed by an external organization); and the impact of significant changes in personnel, organizational structure, or the QA program of the organization scheduled to be audited. The results of these evaluations shall be reflected in the audit schedule and audit scope.

The audit schedule shall identify the following, as a minimum:

a. Organizations to be Audited;

b. Audit Number;

c. Date of Audit; and

d. ATL.

6.1.2 The Director, OQA shall, on a quarterly basis, review and update the audit schedule. The transmittal of updated schedules shall identify any cancellations or major delays in the previously scheduled audits with the justification for the cancellations or delays.

6.1.3 Following Director, OQA approval, the audit schedule and quarterly updates shall be transmitted to the appropriate organizations.

6.1.4 Regularly scheduled audits may be supplemented as necessary.

6.2 AUDIT TEAM SELECTION

6.2.1 The Director, OQA selects an ATL for each audit and shall verify that each ATL is certified as a lead auditor.

6.2.2 The ATL shall identify the audit team prior to the audit. The qualification records of each audit team member shall be reviewed by a DOE QA staff member to verify that the individual is qualified to conduct audits and has the necessary technical expertise.

6.2.3 The ATL shall ensure that each audit team member is independent of direct responsibility for the activity to be audited.

6.3 PREPARATION

6.3.1 The ATL shall identify the scope of the audit for inclusion in the audit plan. The scope of an audit may include evaluation of product quality and technical adequacy of work being done or completed, as appropriate, as well as programmatic compliance and implementation effectiveness. Technical requirements may be selected for audit evaluation from the governing technical requirements documents and shall be included in audit checklists prepared by the technical specialists.

6.3.2 A visit to the site of the planned audit and meetings with the organization to be audited should be considered to further define the scope and conduct of the audit.

6.3.3 The ATL shall develop an audit plan that identifies the following:

a. Scope;

b. Audit team Personnel;

c. Requirements;

d. Activities to be Audited;

e. Organizations to be Notified;

f. Applicable Documents;

g. Schedule; and

h. Identification of Procedures or Checklists.

6.3.4 The ATL shall sign and date the audit plan.

6.3.5 The ATL shall prepare an audit notification letter and forward it, along with the audit plan, to the Director, OQA.

6.3.6 The Director, OQA, shall approve and issue the audit plan and notification letter to the appropriate organization.

6.3.7 The audit team shall develop a checklist (see Attachment II), or mark-up procedures to guide their audit activities. Checklist questions shall be based on a review of requirements, procedures, previous audit and surveillance reports, and technical documents, as applicable.

6.3.8 The ATL shall ensure that the audit team is prepared for the audit. Preparation shall include the following:

a. Developing a checklist or marked-up procedures;

b. Studying auditee procedures that apply to the activities being audited;

c. Evaluating previous surveillance and audits results;

d. Evaluating relevant corrective action history;

e. Reviewing current status of the work; and

f. Reviewing trend data.

6.3.9 The ATL shall conduct a preaudit meeting with the audit team to ensure that team members are prepared.

6.4 PERFORMANCE

6.4.1 During the audit, the audit team shall:

a. Perform reviews of documents and records to assess their adequacy and acceptability.

b. Conduct activities in the audit checklist or procedure under the direction of the ATL.

c. Examine objective evidence to the depth necessary to determine if the elements are being implemented effectively.

d. Maintain a list of personnel contacted.

e. Complete the checklist.

6.4.2 The ATL shall conduct a daily team meeting during the conduct of the audit to discuss/report conditions adverse to quality that were found during the audit. The audited organization shall be notified immediately of conditions requiring prompt corrective action.

6.4.3 The ATL shall conduct daily meetings with management of the audited organization to keep them informed about the status of the audit and to keep them involved in the audit.

6.4.4 After completion of the audit, the audit team shall document conditions adverse to quality on a Nonconformance Report (NCR) (item related) in accordance with QMP-15-01, *Control of Nonconformances*, or Corrective Action Request (CAR) (activity related) in accordance with QAAP 16.1, *Corrective Action Requests*. An effectiveness statement (including technical aspects, as appropriate) shall be prepared by each audit team member for the appropriate activities which were audited.

6.4.5 All NCRs, CARs, completed checklists, and effectiveness statements shall be submitted to the ATL.

6.5 POSTAUDIT

6.5.1 The ATL shall conduct a postaudit meeting with the appropriate management and staff members of the audited organization to present the results of the audit. Attendance shall be documented.

6.5.2 The ATL shall process CARs and NCRs in accordance with QAAP 16.1 and QMP-15-01, respectively transmitting the CARs and NCRs to the audited organization. The transmittal letter shall request a response from the affected organization, which: identifies the root cause of each condition adverse to quality (including significant conditions adverse to quality); identifies corrective action to resolve each adverse condition and preclude recurrence; specifies corrective action completion dates; provides an evaluation of impact of the deficient work performed and the generic implications on the program; and identifies corrective action responsibilities.

6.5.3 The Director, OQA, shall approve and issue the CARs and NCRs, with the transmittal letter, to the audited organization.

6.5.4 The ATL/audit team member shall complete and distribute a Trend Data Form for the results of the audit in accordance with QAAP 2.9, *Quality Assurance Program Status and Trend Reporting.*

6.5.5 The Director, OQA shall ensure that auditor qualification records are updated in accordance with QAAP 18.1 and QMP-02-02.

6.6 AUDIT REPORT

6.6.1 The ATL shall prepare a formal audit report, that includes the following information:

a. Audit Scope;

b. Basis for the Audit (e.g. References);

c. Audit Team Members;

d. Date of the Audit;

e. Summary of Audit Results;

f. Effectiveness Statement;

g. List of Personnel Contacted;

h. Description of Conditions Adverse to Quality; and

i. Description of Conditions Corrected During the Audit.

6.6.2 The ATL shall ensure that all relevant information from the checklist or marked-up procedures used by the audit team has been addressed in the Audit Report or associated deficiency reports.

6.6.3 The ATL shall prepare the audit report transmittal letter.

6.6.4 The ATL shall prepare and sign the audit report and forward the transmittal letter, and draft copies of the associated deficiencies (CARs/NCRs) to the Director, OQA.

6.6.5 The audit report and transmittal letter shall be approved by the Director, OQA and distributed to the audited organization. Copies of the audit report shall also be distributed to other affected organization for review, assessment, and appropriate action. The audit is considered closed upon issuance of the audit report.

6.6.6 The responses to associated deficiencies (CARs and NCRs) shall be evaluated against the requirements in Section 6.5.2 for completeness. CARs and NCRs shall be processed in accordance with QAAP 16.1, *Corrective Action Requests*, and QMP-15-01, *Control of Nonconformances*, respectively.

6.7 RECORD PACKAGE COMPLETION

6.7.1 The Director, OQA shall ensure that an audit records package is assembled. The records package shall consist of the following:

a. Audit Plan;

b. Notification Letter;

c. CAR/NCR (Information Copies);

d. Audit Report; and

e. Pre-Conference and Post-Conference Attendance Record.

6.7.2 The completed audit record package shall be submitted to the Quality Records Center in accordance with QAAP 17.1, *QA Records Management*.

7.0 RECORDS

Records generated as a result of this procedure shall be processed and maintained in accordance with requirements specified in QAAP 17.1. At a minimum, the documents listed in paragraph 6.7.1 and the Audit Schedules are considered records.

Note: CAR and NCR record packages shall be maintained as QA records separately from the audit record package.

8.0 ATTACHMENTS

8.1 Attachment I - Audit Plan Format (Example)
8.2 Attachment II - Quality Assurance Checklist
8.3 Attachment III - Quality Assurance Checklist (Continuation Sheet)
8.4 Attachment IV - Attendance Record
8.5 Attachment V - Quality Assurance Audit Report

ATTACHMENT I
Example of Audit Plan Format

Audit Number: _____

Organization: _____

Location of Audit: _____

Dates of Audit: _____

Audit Team Members: _____

_____

_____

AUDIT SCOPE

Activities/Contracts/Tasks to be Audited: _____

_____

Requirements/Criteria to be Audited: _____

_____

Governing Documents: _____

_____

_____

PRELIMINARY AUDIT SCHEDULE:

Pre-audit Meeting: _____

Conduct of Audit: _____

_____

_____

Daily Team Debriefing Time and Location: _____

_____

Post-audit Meeting Date, Time and Location: _____

_____
ATL /DATE

ATTACHMENT II (TYPICAL)

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
U.S. DEPARTMENT OF ENERGY
WASHINGTON, D.C.

SHEET ___ OF ___
AUDIT/SURVEILLANCE/INSPECTION NO. ___

QUALITY ASSURANCE CHECKLIST

ORGANIZATION EVALUATED	[ ] EXTERNAL [ ] INTERNAL	[ ] AUDIT [ ] SURVEILLANCE [ ] INSPECTION	PREPARED BY ___ DATE ___ CONCURRED BY ___ DATE ___ APPROVED BY ___ DATE ___
DATE(S) OF EVALUATION			
CONTROLLING DOCUMENT (Title, Number, Revision)			ACTIVITY EVALUATED

ITEM NO.	CHARACTERISTIC TO BE EVALUATED	REMARKS Record objective evidence reviewed, method of verification, personnel contacted	* RESULTS

* INDICATE RESULTS: SATISFACTORY (SAT), UNSATISFACTORY (UNSAT), NOT APPLICABLE (N/A)

REV 1/89

ATTACHMENT III (TYPICAL)

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
U.S. DEPARTMENT OF ENERGY
WASHINGTON, D.C.

SHEET ____ OF ____
AUDIT/SURVEILLANCE/INSPECTION NO ____

QUALITY ASSURANCE CHECKLIST (continuation sheet)

ITEM NO	CHARACTERISTIC TO BE EVALUATED	REMARKS Record objective evidence reviewed, method of verification, personnel contacted	RESULTS

REV 1/89

ATTACHMENT IV (TYPICAL)

SHEET ___ OF ___
WBS NO _____

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
U.S. DEPARTMENT OF ENERGY
WASHINGTON, D.C.

ATTENDANCE RECORD

[ ] AUDIT [ ] SURVEILLANCE [ ] TRAINING/INDOCTRINATION	SUBJECT	[ ] TEAM BRIEFING [ ] PRE-CONFERENCE [ ] POST-CONFERENCE

AUDIT OR SURVEILLANCE LEADER/INSTRUCTOR(S)

_____ DATE _____
Signature

_____
Signature CLASS LENGTH _____

BRIEF SUMMARY OF MATERIAL COVERED _____

NAME OF ATTENDEE PRINTED	SIGNATURE	ORGANIZATION/ COMPANY	POSITION/TITLE	PHONE NUMBER

REV. 3/89

ATTACHMENT V (EXAMPLE)
QUALITY ASSURANCE AUDIT REPORT
(Suggest Format)

Audit No.

_____

Organization Audited:

_____

Dates of Audit:

_____

Audit Team Members:

_____ _____
_____ _____
_____ _____

1.0 Scope of Audit
Describe the scope (including such things as "verified by review of objective evidence that _____ has an effectively document and implemented Quality Assurance Program...")

2.0 Personnel Contacted

W. Doe	1,2,3	Project Manager	1=attended preaudit meeting
J. Smith	2	Engineer	2=contact during audit
G. Jones	3	Technician	3=attended postaudit meeting
A. Wade	1,2,3	QA Manager	

3.0 Executive Summary of Audit Results
As a result of the audit, _____ Nonconformance Reports (NCR) and _____ Corrective Action Requests (CAR) were issued for the criteria audited.

3.1 Describe positive points as well as problematic areas. The summary should be brief, and should identify major and minor concerns or problems.

3.2 Summarize and discuss audit findings here. Reference NCR and CAR numbers.

3.3 Describe any comments or recommendations here.

4.0 Definitions
Include any definitions that would enhance and facilitate understanding of the audit report.

5.0 Effectiveness
Include a statement on the effectiveness of the quality assurance program elements audited. The statement should reflect whether the QA program is meaningful as applicable to the scope of work and whether it is effectively implemented.

Issued: _____ Date: _____
(Audit Team Leader)

Approved: _____ Date: _____

QUALITY ASSURANCE ADMINISTRATIVE PROCEDURE

18.2, REV. 3

The following number is for OCRWM records management purposes only and should not be used when ordering this publication.

Accession No.: HQO.901130.0001

Los Alamos
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

WBS 1.2.9.3
QA N/A

memorandum

TO: Richard Powe, SAIC

DATE: February 11, 1991

FROM: S. L. Bolivar, EES-13

MAIL STOP/TELEPHONE: J521/7-1868

SYMBOL: TWS-ESS-13-02-91-038

SUBJECT: **TECHNICAL HOST FOR PROJECT OFFICE QA AUDIT**

We have selected two technical hosts to assist with the upcoming QA audit. In the past, technical hosts have greatly helped facilitate the audit process. I've enclosed a memo describing their anticipated responsibilities.

SLB/lmm

Encl.: a/s

Cy w/o encl. (Limited Value Material):
D. A. Broxton, EES-1, MS D462
J. A. Canepa, EES-13, MS J521
J. L. Day, LATA, MS M321
R. J. Herbst, EES-13, MS J521
K. A. West, EES-13, MS J521
RPC File (2), MS M321
TWS-EES-13, MS J521

Los Alamos
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

WBS 1.2.9.3
QA N/A

memorandum

TO: D. E. Broxton, EES-1, MS D462 DATE: February 11, 1991

FROM: S. L. Bolivar, EES-13 MAIL STOP/TELEPHONE: J521/7-1868

SYMBOL: TWS-EES-13-02-91-036

SUBJECT: **TECHNICAL HOST–PROJECT OFFICE QA AUDIT**

Thanks for agreeing to co-host with Karen West the upcoming Project Office QA audit. This audit is scheduled for the week of March 25, 1991.

My expectations are that you will facilitate the audit by

- reviewing the audit scope and the associated records in anticipation of the audit,
- attending to the audit team's technical needs during the audit,
- answering or obtaining answers as appropriate to audit team technical inquiries, and
- expediting any corrective actions that may need to be taken by us during the audit.

I see these responsibilities requiring no less than a quarter of your time between now and the audit and full time during the week of the audit.

To help you succeed in this assignment, I am advising the Lead Auditor of your role and my expectations. I am also advising the Los Alamos staff by copy of this memo of the role you will be playing. I urge the staff to discuss any questions or concerns they have before or during the audit with you or Karen.

SLB/lmm

Cy:
PI Distribution List
TWS-EES-13 File, MS J521
RPC File (2), MS M321

WORK SHEET FOR EVALUATION OF CHARACTERISTICS

N-QA-094
02/90

TITLE OF ITEM [ ] OR ACTIVITY [X] WBS 1.2.3.2
Geology (Mineralogy, Petrology and Pathways)- See Attachment 1

REPORT NO. 1 **REV. NO.** 0
RESPONSIBLE ORGANIZATION Los Alamos National Laboratory
NAME OF PREPARER Schon S. Levy/Henry P. Nunes

CHARACTERISTIC **EVALUATION STATEMENT**

1. REPRODUCIBILITY OR EASE OF REPLACEMENT:

It would be difficult to reproduce or replace the results of this activity.

2. COMPLEXITY:

The process is complex, i.e., a high level of geologic expertise is required to collect and characterize samples.

3. QUALITY HISTORY:

There is a good history of quality assurance, as applied to this activity. Similar work has been done and published in technical journals. The techniques have wide acceptance in the geologic community.

4. STANDARDIZATION:

The sample preparation and use of analytical equipment has been standardized for the YMP.

5. AVAILABLE CODES AND STANDARDS:

No codes available. Analytical standards accepted within the geological community for electron microprobe and x-ray diffractors are used.

6. NEED FOR PROCESS CONTROL:

LANL has no processes or special processes, as defined in the QARD.

7. SPECIAL HANDLING, SHIPPING, AND STORAGE:

Special handling, shipping, and storage requirements, as defined in the QARD, do apply to this work.

H.P. Nunes 12/20/90 S.S. Levy 12/20/90
PREPARER (Signature and Date)

QUALITY ASSURANCE GRADING REPORT

N-QA-095
7/90

PART I. IDENTIFICATION AND DEFINITION: ☐ ITEM ☒ ACTIVITY

TITLE/DESCRIPTION Geology (Mineralogy, Petrology, and Pathways) - See Attachment 1 **REPORT NO.** 1 **REV. NO.** 0

RESPONSIBLE ORGANIZATION Los Alamos National Laboratory

REVISION(S) OF Q-LIST, QUALITY ACTIVITIES LIST, PROJECT REQUIREMENTS LIST, AND SUPPORTING DOCUMENTATION USED:
WBS 1.2.3.2, Quality Activities List, R0, Page 7 of 17 (See Attachment 1)

(Attach additional definitive information as necessary to fully define the subject item or activity and support the position expressed in this QAG report)

PART II. STATEMENT OF IMPORTANCE

Section A: (Check the appropriate areas) ☐ Public Radiological Safety (Q-List) ☐ Waste Isolation (Q-List)

☐ Performance Assessment (QAL) ☒ Site Characterization (QAL) ☐ Potential Adverse Impact on Natural Barrier(s) (QAL) ☐ NA (Complete Section B)

Section B: (Check the appropriate areas) ☐ Worker Radiological Safety (Att:) ☐ Operational Reliability (Att:)

☐ Other (Provide explanation) (Att:) ☒ N/A (Provide explanation) (Att: 1)

PART III. GRADING

QA CRITERIA	APPLICABLE (YES OR NO)	JUSTIFICATION IF NOT APPLICABLE (REFERENCE)*	EXCEPTION(S) TO CRITERIA SUBPARTS (REFERENCE)*
1. ORGANIZATION	Yes	N/A	No Exceptions
2. QA PROGRAM	Yes	N/A	No Exceptions
3. DESIGN CONTROL	No	See Attachment 2	N/A
4. PROCUREMENT DOCUMENT CONTROL	Yes	N/A	See Attachment 2
5. PLANS, PROCEDURES, INSTRUCTIONS, AND DRAWINGS	Yes	N/A	No Exceptions
6. DOCUMENT CONTROL	Yes	N/A	No Exceptions
7. CONTROL OF PURCHASED ITEMS AND SERVICES	Yes	N/A	See Attachment 2
8. IDENT. & CONTROL OF MTRLS, PARTS, CMPNTS, & SMPLS	Yes	N/A	No Exceptions
9. CONTROL OF PROCESSES	No	See Attachment 2	N/A
10. INSPECTION	No	See Attachment 2	N/A
11. TEST CONTROL	No	See Attachment 2	N/A
12. CONTROL OF MEASURING AND TESTING EQUIPMENT	Yes	N/A	No Exceptions
13. HANDLING, STORAGE, AND SHIPPING	Yes	N/A	No Exceptions
14. INSPECTION, TEST, AND OPERATING STATUS	No	See Attachment 2	N/A
15. CONTROL OF NONCONFORMING CONDITIONS	Yes	N/A	No Exceptions
16. CORRECTIVE ACTION	Yes	N/A	No Exceptions
17. QA RECORDS	Yes	N/A	No Exceptions
18. AUDITS	Yes	N/A	No Exceptions
19. COMPUTER SOFTWARE	Yes	N/A	No Exceptions
20. SCIENTIFIC INVESTIGATION CONTROL	Yes	N/A	No Exceptions

* Reference attached justification or explanations

PART IV. APPROVALS:

HPMunos 12/20/90
Preparer's Signature Date

HPMunos 12/20/90
A Manager's Signature Date

12/20/90
TPO's Signatur Date

QRB ACCEPTANCE:

12/20/90
QRB Chairman's Signature Date

PART I, IDENTIFICATION AND DEFINITION, TITLE OF ACTIVITY:

Mineralogy, Petrology, and Chemistry of Transport Pathways, and History of Mineralogic and Geologic Alteration of Yucca Mountain

PART I, IDENTIFICATION AND DEFINITION, DESCRIPTION OF ACTIVITY:

MINERALOGY, PETROLOGY, AND CHEMISTRY OF TRANSPORT PATHWAYS

WBS 1.2.3.2.1.1.1
(YMP-LANL-SP 8.3.1.3.2.1, R3)

The mineralogy, petrology and chemistry of pathways test is designed (1) to determine the three dimensional distribution of mineral types, compositions, abundances, and petrographic textures within the potential host rock, and (2) to determine the three-dimensional distribution of mineral types, composition, and abundances in rocks beyond the host rock that provide pathways to the accessible environments. This study will provide input into the assessment of retardation by sorption, and to the geologic framework of Yucca Mountain. [The analysis of mineral types, abundances, and distributions beneath Yucca Mountain is required by each of these information needs and investigations.] There are three activities within this study: petrologic stratigraphy of the Topopah Spring member, mineral distributions between the host rock and the accessible environment, and fracture mineralogy.

HISTORY OF MINERALOGIC AND GEOLOGIC ALTERATION OF YUCCA MOUNTAIN

WBS 1.2.3.2.1.1.2
(YMP-LANL-SP 8.3.1.3.2.2, R0)

The objective of the history of mineralogic and geochemical alteration of Yucca Mountain study is to characterize past and present natural alteration processes that have affected the potential geologic repository at Yucca Mountain and to predict future effects of natural and repository induced alteration. This study consists of two activities: the history of mineralogic and geochemical alteration activity and the activity concerned with dehydration and transformation of smectite, zeolite, manganese and iron minerals, and glass. The alteration history activity involves the study of altered rocks from drill holes, outcrops, and mined shafts and drifts, and the reconstruction of a chronology of alteration events and processes from that study. The mineral and glass dehydration and transformation activity investigates structural and chemical changes to minerals and glasses in laboratory experiments designed to simulate thermal and hydrologic conditions surrounding the potential mined repository.

PART I. IDENTIFICATION AND DEFINITION, REVISIONS OF Q-LIST, QUALITY ACTIVITIES LIST, PROJECT REQUIREMENTS LIST, AND SUPPORTING DOCUMENTATION USED:

Quality Activities List (QAL), RO, Page 7 of 17, WBS 1.2.3.2, as applied to:
WBS 1.2.3.2.1.1.1 (YMP-LANL-SP 8.3.1.3.2.1, R3), and
WBS 1.2.3.2.1.1.2 (YMP-LANL-SP 8.3.1.3.2.2, RO), dated June 1990

PART II, STATEMENT OF IMPORTANCE, SECTION B, OTHER:

There are no worker radiological or operational reliability issues associated with this work.

PART III, GRADING:

QARD Section 3, Design Control: This activity involves no design related tasks or design responsibility.

QARD Section 4, Procurement Document Control, Exceptions to NQA-1, Supplement 4S-1

Subsection 2.7: The LANL scope of work does not involve engineered products for which there is a need to provide spare and replacement parts.

QARD Section 7, Control of Purchased Items and Services, Exceptions to NQA-1, Supplement 7S-1:

Subsection 4, **Bid Evaluation:** Deletion of this subsection will not compromise the quality of the special services products. Each of these products are evaluated upon receipt by the LANL technical staff for final acceptance prior to their use. All other procurements are commercial grade and are inspected to ensure that the items received are the items ordered and undamaged.

QARD Section 9, Control of Processes: This section does not apply because this task does not involve any special process as defined the QARD.

QARD Section 10, Inspection: This section does not apply because there are no inspections performed by LANL except those as defined for receiving commercial grade items under the procurement process. Deletion of these requirements will not adversely impact the quality of the items or services received by LANL.

QARD Section 11, Test Control: No tests are conducted as a part of this activity. Computer program tests are conducted in accordance with QARD Section 19, Computer Software, Subsection 19.1.2, d. Testing Phase, as defined in the LANL Software QA Program Plan and implementing procedures.

QARD Section 14, Inspection, Test, and Operating Status: The LANL activities require no identification or control of inspection, test, or operating status.

WORK SHEET FOR EVALUATION OF CHARACTERISTICS N-QA-094 02/90

TITLE OF ITEM [ ] OR ACTIVITY [X] **PAGE** 1 **OF** 4
WBS 1.2.3.3.1, Geohydrology, Water Movement Tracer Tests
REPORT NO. 10 **REV. NO.** 0
RESPONSIBLE ORGANIZATION Los Alamos National Laboratory
NAME OF PREPARER H. P. Nunes

CHARACTERISTIC **EVALUATION STATEMENT** INFORMATION COPY

1. REPRODUCIBILITY OR EASE OF REPLACEMENT:

It would be difficult to reproduce or replace the results of this activity.

2. COMPLEXITY:

The work is complex. A high level of geologic expertise is required to collect and characterize samples and data.

3. QUALITY HISTORY:

There is a good history of QA applied to this activity.

4. STANDARDIZATION:

None.

5. AVAILABLE CODES AND STANDARDS:

None.

6. NEED FOR PROCESS CONTROL:

LANL has no processes or special processes as defined in the QARD.

7. SPECIAL HANDLING, SHIPPING, AND STORAGE:

Special handling, shipping and storage requirements as defined in the QARD, do apply to this work.

HPNunes 1/7/91
PREPARER (Signature and Date)

ENCLOSURE 2

QUALITY ASSURANCE GRADING REPORT

N-QA-095
7/90

PART I. IDENTIFICATION AND DEFINITION: ☐ ITEM ☒ ACTIVITY PAGE 2 OF 4

TITLE/DESCRIPTION Geohydrology (See Attachment 1) **REPORT NO.** 10 **REV. NO.** 0

RESPONSIBLE ORGANIZATION Los Alamos National Laboratory

REVISION(S) OF Q-LIST, QUALITY ACTIVITIES LIST, PROJECT REQUIREMENTS LIST, AND SUPPORTING DOCUMENTATION USED:
WBS 1.2.3.3.1, QAL, R1, Pg. 7 of 17

(Attach additional definitive information as necessary to fully define the subject item or activity and support the position expressed in this QAG report)

PART II. STATEMENT OF IMPORTANCE

Section A: (Check the appropriate areas) ☐ Public Radiological Safety (Q-List) ☐ Waste Isolation (Q-List)

☐ Performance Assessment (QAL) ☒ Site Characterization (QAL) ☒ Potential Adverse Impact on Natural Barrier(s) (QAL) ☐ NA (Complete Section B)

Section B: (Check the appropriate areas) ☐ Worker Radiological Safety (Att:) ☐ Operational Reliability (Att:)

☐ Other (Provide explanation) (Att:) ☒ N/A (Provide explanation) (Att: 1)

PART III. GRADING

QA CRITERIA	APPLICABLE (YES OR NO)	JUSTIFICATION IF NOT APPLICABLE (REFERENCE)*	EXCEPTION(S) TO CRITERIA SUBPARTS (REFERENCE)*
1. ORGANIZATION	Yes	N/A	No Exceptions
2. QA PROGRAM	Yes	N/A	No Exceptions
3. DESIGN CONTROL	No	See Attachment 2	N/A
4. PROCUREMENT DOCUMENT CONTROL	Yes	N/A	See Attachment 2
5. PLANS, PROCEDURES, INSTRUCTIONS, AND DRAWINGS	Yes	N/A	No Exceptions
6. DOCUMENT CONTROL	Yes	N/A	No Exceptions
7. CONTROL OF PURCHASED ITEMS AND SERVICES	Yes	N/A	See Attachment 2
8. IDENT. & CONTROL OF MTRLS, PARTS, CMPNTS, & SMPLS	Yes	N/A	No Exceptions
9. CONTROL OF PROCESSES	No	See Attachment 2	N/A
10. INSPECTION	No	See Attachment 2	N/A
11. TEST CONTROL	No	See Attachment 2	N/A
12. CONTROL OF MEASURING AND TESTING EQUIPMENT	Yes	N/A	No Exceptions
13. HANDLING, STORAGE, AND SHIPPING	Yes	N/A	No Exceptions
14. INSPECTION, TEST, AND OPERATING STATUS	No	See Attachment 2	N/A
15. CONTROL OF NONCONFORMING CONDITIONS	No	See Attachment 2	N/A
16. CORRECTIVE ACTION	Yes	N/A	No Exceptions
17. QA RECORDS	Yes	N/A	No Exceptions
18. AUDITS	Yes	N/A	No Exceptions
19. COMPUTER SOFTWARE	Yes	N/A	No Exceptions
20. SCIENTIFIC INVESTIGATION CONTROL	Yes	N/A	No Exceptions

* Reference attached justification or explanations

PART IV. APPROVALS:

Preparer's Signature — Date 1/7/91

Q. Manager's Signature — Date 1/7/91

TPO's Signature — Date 1/7/91

QRB ACCEPTANCE:

QRB Chairman's Signature — Date 1/31/91

PART I, IDENTIFICATION AND DEFINITION, TITLE OF ACTIVITY:

Water movement tracer tests, diffusion tests in the exploratory shaft, site saturated zone ground-water flow system modeling, and saturated zone hydrochemistry.

PART I, IDENTIFICATION AND DEFINITION, DESCRIPTION OF ACTIVITY:

- The water movement tracer tests will quantify the amount of percolation from precipitation into the unsaturated zone at Yucca Mountain.
- The diffusion test will model the transport of technetium-99 and in iodine-129 from the repository to the water table.
- The flow system modeling will perform multi-well inference testing at the C-hole complex, determine the fractured media model, evaluate hydraulic properties, and characterize the chemical and physical properties of the geologic media in the saturated zone, both at the C-well site and Yucca Mountain in general.
- Saturated zone hydrochemistry will evaluate hydrochemical data availability and needs, describe the hydrochemistry of the upper 100 meters of the saturated zone, describe regional spatial variations in the ground-water chemistry, and identify the chemical and physical processes that influence ground-water chemistry and aid in quantification of ground-water travel times with the use of graphical and geochemical models.

PART II, STATEMENT OF IMPORTANCE, SECTION B, OTHER:

There are no worker radiological or operational reliability issues associated with this work.

PART III, GRADING:

QARD Section 3, Design Control: This activity involves no design related tasks or design responsibility.

QARD Section 4, Procurement Document Control, Exceptions to NQA-1, Supplement 4S-1

Subsection 2.7: The LANL scope of work does not involve engineered products for which there is a need to provide spare and replacement parts.

QARD Section 7, Control of Purchased Items and Services, Exceptions to NQA-1, Supplement 7S-1:

Subsection 4, Bid Evaluation: Deletion of this subsection will not compromise the quality of the special services products. Each of these products are evaluated upon receipt by the LANL technical staff for final acceptance prior to their use. All other procurements are commercial grade and are inspected to ensure that the items received are the items ordered and undamaged.

QARD Section 9, Control of Processes: This section does not apply because this task does not involve any special process as defined the QARD.

QARD Section 10, Inspection: This section does not apply because there are no inspections performed by LANL except those as defined for receiving commercial grade items under the procurement process. Deletion of these requirements will not adversely impact the quality of the items or services received by LANL.

QARD Section 11, Test Control: No tests are conducted as a part of this activity. Computer program tests are conducted in accordance with QARD Section 19, Computer Software, Subsection 19.1.2, d. Testing Phase, as defined in the LANL Software QA Program Plan and implementing procedures.

QARD Section 14, Inspection, Test, and Operating Status: The LANL activities require no identification or control of inspection, test, or operating status.

QARD Section 15, Control of Nonconforming Items: This activity does not involve any engineered items for which this section is applicable.

WORK SHEET FOR EVALUATION OF CHARACTERISTICS N-QA-094 02/90

TITLE OF ITEM [ ] OR ACTIVITY [X] PAGE 1 OF 4
WBS 1.2.3.4, Geochemistry
REPORT NO. 11 **REV. NO.** 0
RESPONSIBLE ORGANIZATION Los Alamos National Laboratory
NAME OF PREPARER H. P. Nunes

CHARACTERISTIC **EVALUATION STATEMENT** INFORMATION COPY

1. REPRODUCIBILITY OR EASE OF REPLACEMENT:

It would be difficult to reproduce or replace the results of this activity.

2. COMPLEXITY:

The work is complex. A high level of geologic expertise is required to collect and characterize samples and data.

3. QUALITY HISTORY:

There is a good history of QA applied to this activity.

4. STANDARDIZATION:

None.

5. AVAILABLE CODES AND STANDARDS:

None.

6. NEED FOR PROCESS CONTROL:

LANL has no processes or special processes, as defined in the QARD.

7. SPECIAL HANDLING, SHIPPING, AND STORAGE:

Special handling, shipping, and storage requirements, as defined in the QARD, do apply to this work.

HPNunes 1/7/91
PREPARER (Signature and Date)

ENCLOSURE 2

QUALITY ASSURANCE GRADING REPORT

N-QA-095
7/90

PART I. IDENTIFICATION AND DEFINITION: ☐ ITEM ☒ ACTIVITY

TITLE/DESCRIPTION Geochemistry (See Attachment 1) **REPORT NO.** 11 **REV. NO.** 0

RESPONSIBLE ORGANIZATION Los Alamos National Laboratory

REVISION(S) OF Q-LIST, QUALITY ACTIVITIES LIST, PROJECT REQUIREMENTS LIST, AND SUPPORTING DOCUMENTATION USED:
WBS 1.2.3.4, QAL, R1, Page 8 of 17

(Attach additional definitive information as necessary to fully define the subject item or activity and support the position expressed in this QAG report)

PART II. STATEMENT OF IMPORTANCE

Section A: (Check the appropriate areas) ☐ Public Radiological Safety (Q-List) ☐ Waste Isolation (Q-List)

☐ Performance Assessment (QAL) ☒ Site Characterization (QAL) ☒ Potential Adverse Impact on Natural Barrier(s) (QAL) ☐ NA (Complete Section B)

Section B: (Check the appropriate areas) ☐ Worker Radiological Safety (Att:) ☐ Operational Reliability (Att:)

☐ Other (Provide explanation) (Att:) ☒ N/A (Provide explanation) (Att: 1)

PART III. GRADING

QA CRITERIA	APPLICABLE (YES OR NO)	JUSTIFICATION IF NOT APPLICABLE (REFERENCE)*	EXCEPTION(S) TO CRITERIA SUBPARTS (REFERENCE)*
1. ORGANIZATION	Yes	N/A	No Exceptions
2. QA PROGRAM	Yes	N/A	No Exceptions
3. DESIGN CONTROL	No	See Attachment 2	N/A
4. PROCUREMENT DOCUMENT CONTROL	Yes	N/A	See Attachment 2
5. PLANS, PROCEDURES, INSTRUCTIONS, AND DRAWINGS	Yes	N/A	No Exceptions
6. DOCUMENT CONTROL	Yes	N/A	No Exceptions
7. CONTROL OF PURCHASED ITEMS AND SERVICES	Yes	N/A	See Attachment 2
8. IDENT. & CONTROL OF MTRLS, PARTS, CMPNTS, & SMPLS	Yes	N/A	No Exceptions
9. CONTROL OF PROCESSES	No	See Attachment 2	N/A
10. INSPECTION	No	See Attachment 2	N/A
11. TEST CONTROL	No	See Attachment 2	N/A
12. CONTROL OF MEASURING AND TESTING EQUIPMENT	Yes	N/A	No Exceptions
13. HANDLING, STORAGE, AND SHIPPING	Yes	N/A	No Exceptions
14. INSPECTION, TEST, AND OPERATING STATUS	No	See Attachment 2	N/A
15. CONTROL OF NONCONFORMING CONDITIONS	No	See Attachment 2	N/A
16. CORRECTIVE ACTION	Yes	N/A	No Exceptions
17. QA RECORDS	Yes	N/A	No Exceptions
18. AUDITS	Yes	N/A	No Exceptions
19. COMPUTER SOFTWARE	Yes	N/A	No Exceptions
20. SCIENTIFIC INVESTIGATION CONTROL	Yes	N/A	No Exceptions

* Reference attached justification or explanations

PART IV. APPROVALS:

Preparer's Signature — Date: 1/7/91

QA Manager's Signature — Date: 1/7/91

TPO's Signature — Date: 1/7/91

QRB ACCEPTANCE:

QRB Chairman's Signature — Date: 1/9/91

PART I, IDENTIFICATION AND DEFINITION, TITLE OF ACTIVITY:

Geochemical Investigations including: ground-water chemistry modeling, batch sorption studies and models, biological sorption and transport studies, dissolved species concentration limits, colloid behavior studies, dynamic transport column studies, diffusion studies, retardation sensitivity analysis modeling, applicability of laboratory data to transport calculations, and gaseous radionuclides retardation studies.

PART I, IDENTIFICATION AND DEFINITION, DESCRIPTION OF ACTIVITY:

Geochemistry investigations include all efforts necessary to:

- determine host rock geochemistry,
- determine kinetics of reaction or potential Eh-controlling mineral phases,
- determine the geochemical composition of the pore fluid in the unsaturated zone,
- describe ground-water chemistry,
- determine the effect of hydrothermal conditions on the geochemical and hydraulic environment,
- identify and analyze the dominant retardation processes that occur in the hydrostratigraphic units encountered,
- develop mathematical models that describe the chemical, geochemical, and hydraulic processes that are dominant in the hydrostratigraphic units in Yucca Mountain, and
- investigate the application of natural analogues to the Yucca Mountain Project geochemical environment.

PART II, STATEMENT OF IMPORTANCE, SECTION B, OTHER:

There are no worker radiological or operational reliability issues associated with this work.

PART III, GRADING:

QARD Section 3, Design Control: This activity involves no design related tasks or design responsibility.

QARD Section 4, Procurement Document Control, Exceptions to NQA-1, Supplement 4S-1

Subsection 2.7: The LANL scope of work does not involve engineered products for which there is a need to provide spare and replacement parts.

QARD Section 7, Control of Purchased Items and Services, Exceptions to NQA-1, Supplement 7S-1:

Subsection 4, Bid Evaluation: Deletion of this subsection will not compromise the quality of the special services products. Each of these products are evaluated upon receipt by the LANL technical staff for final acceptance prior to their use. All other procurements are commercial grade and are inspected to ensure that the items received are the items ordered and undamaged.

QARD Section 9, Control of Processes: This section does not apply because this task does not involve any special process as defined the QARD.

QARD Section 10, Inspection: This section does not apply because there are no inspections performed by LANL except those as defined for receiving commercial grade items under the procurement process. Deletion of these requirements will not adversely impact the quality of the items or services received by LANL.

QARD Section 11, Test Control: No tests are conducted as a part of this activity. Computer program tests are conducted in accordance with QARD Section 19, Computer Software, Subsection 19.1.2, d. Testing Phase, as defined in the LANL Software QA Program Plan and implementing procedures.

QARD Section 14, Inspection, Test, and Operating Status: The LANL activities require no identification or control of inspection, test, or operating status.

QARD Section 15, Control of Nonconforming Items: This activity does not involve any engineered items for which this section is applicable.

STUDY PLANS

Terry Grant, SAIC, Rm 262, ext. 4-7647, has status of all study plans

As of 2/7/91, status of study plans of interest to LANL 91-03 auditors are:

	SCP Ref.		WBS Ref.
1.	8.3.1.3.2.1	Mineralogy, Petrology, and Rock Chemistry of Transport Pathways Issued Rev. 0 Jun 1989	1.2.3.2.1.1.1
2.	8.3.1.3.2.2	Mineralogic and Geochemical Alteration A 10/90 comment resolution draft was submitted to the project on 10/17/90.	1.2.3.2.1.1.2
3.	8.3.1.3.3	Stability of Minerals and Glasses There is no study plan at this level. A 2/89 draft study plan for the following has been submitted to the project for comment. Comments were given to LANL. Comment resolution meeting was held 3/90. Awaiting comment resolution draft.	1.2.3.2.1.2
	8.3.1.3.3.2 & 8.3.1.3.3.3	Kinetics and Thermodynamics of Mineral Evolution and Conceptual Model of Mineral Evolution A study plan for 8.3.1.3.3.1 Natural Analog of Hydrothermal Systems in Tuff has not yet been generated.	
4.	8.3.1.2.2.2	Water Movement Tests Issued Rev. 0 Jan. 1989	1.2.3.3.1.2.2
5.	8.3.1.3.1	Ground-Water Chemistry Model No study plan at project level yet. A draft plan is undergoing internal review at LANL.	1.2.3.4.1.1

Study Plan for
Study 8.3.1.3.2.1

Study Plan for Mineralogy, Petrology, and Chemistry of Transport Pathways

Revision 0

June 1989

U.S. Department of Energy
Office of Civilian Radioactive Waste Management
Washington, DC 20585

Prepared by
Los Alamos National Laboratory

Study Plan Number 8.3.1.3.2.1

Study Plan Title Study Plan for Mineralogy, Petrology and Chemistry of Transport Pathways

Revision Number RO; June, 1989

Prepared by:

Los Alamos National Laboratory

Date:

June, 1989

Maxwell Blanford 6-12-89
Director, Regulatory and Site Evaluation Division Date

James Blaylock 6/13/89
Project Quality Manager Date

Carl Gertz 6/13/89
Project Manager Date

MINERALOGY, PETROLOGY, AND CHEMISTRY OF TRANSPORT PATHWAYS

Los Alamos National Laboratory

ABSTRACT

The mineralogy, petrology and chemistry of pathways test is designed (1) to determine the three-dimensional distribution of mineral types, compositions, abundances, and petrographic textures within the potential host rock, and (2) to determine the three-dimensional distribution of mineral types, composition, and abundances in rocks beyond the host rock that provide pathways to the accessible environments. This study will provide input into the assessment of retardation by sorption, and to the geologic framework of Yucca Mountain. [The analysis of mineral types, abundances, and distributions beneath Yucca Mountain is required by each of these information needs and investigations.] There are three activities within this study: petrologic stratigraphy of the Topopah Spring member, mineral distributions between the host rock and the accessible environment, and fracture mineralogy.

CONTENTS

CONTENTS (cont'd.)

STUDY PLAN FOR MINERALOGY, PETROLOGY, AND CHEMISTRY OF TRANSPORT PATHWAYS

1. PURPOSE AND OBJECTIVES OF STUDIES

1.1 Purpose

The geochemical environment of Yucca Mountain may affect the long-term performance of the repository by retarding the transport of radionuclides by groundwater. The purpose of this Study is to characterize the mineralogy, petrology, and chemistry along potential groundwater flow paths leading from the repository to the accessible environment. Data gathered in this Study will provide information about the types, abundances, distributions, compositions, and textural relationships of minerals along potential groundwater pathways. This information will be used in conjunction with data from sorption experiments (SCP Investigation 8.3.1.3.4) to evaluate radionuclide retardation by sorption processes along flow paths to the accessible environment. Calculational models (SCP 8.3.5.13.3) will use radionuclide retardation factors based on sorption experiments and mineralogic data from this Study to resolve Performance Issue 1.1.6 (probabilistic estimates of radionuclide releases to the accessible environment considering anticipated and unanticipated scenarios).

Groundwater flow paths at Yucca Mountain are not well defined for either present or future hydrologic conditions. These flow paths must be determined to address the performance objective for pre-waste-emplacement groundwater travel time as required by 10 CFR 60.113 and will be defined in SCP activity 8.3.1.2.2.10.3 for the unsaturated zone and activity 8.3.1.2.3.3.3 for the saturated zone. Therefore, at present, this Study must characterize the rock-matrix and fracture-lining minerals along all possible flow paths between the repository and the accessible environment. Our Study will characterize the mineralogy, petrology, and chemistry of rocks occurring along the following types of potential groundwater transport pathways:

- In the unsaturated zone, downward porous matrix flow of groundwater from the repository to the water table.
- In the unsaturated zone, downward transport of groundwater by fracture flow from the repository to the water table.
- In the saturated zone, lateral transport of groundwater by porous matrix flow.
- In the saturated zone, lateral transport of groundwater by fracture flow.

This Study Plan is based upon section 8.3.1.3.2.1 of the Site Characterization Plan (SCP) and includes all three activities discussed in that section. These activities are: 1) Petrologic stratigraphy of the Topopah Spring Member (8.3.1.3.2.1.1), 2) mineral distributions between the host rock and accessible environment (8.3.1.3.2.1.2), and 3) fracture mineralogy (8.3.1.3.2.1.3). This Study Plan is intimately tied to SCP activity 8.3.1.3.2.2 (alteration history), and together both Study Plans define a methodology for identifying the important mineralogic and geochemical properties in the candidate host rock and along groundwater flow paths at Yucca Mountain.

1.2 Rationale and Justification

Collection of these data is required to meet the requirements of 40 CFR Part 191, 10 CFR Part 60, and 10 CFR Part 960; these data will play an important role in resolving Issue 1 (will the mined geologic disposal system at Yucca Mountain isolate the radioactive waste from the accessible environment after closure?). In addition, the data collected in this Study will be used to evaluate the Yucca Mountain site in terms of the siting guidelines outlined in 10 CFR Part 960 and siting criteria

in 10 CFR Part 60. In particular, Issue 1.8 (can the demonstrations for favorable and potentially adverse conditions be made as required by 10 CFR 60.122?) and Issue 1.9 (can the higher level findings required by 10 CFR Part 60 be made for qualifying conditions on the postclosure guideline and the disqualifying and qualifying conditions on the technical guidelines for geohydrology, geochemistry, rock characteristics, climate changes, erosion, dissolution, tectonics, and human interference; and can the comparative evaluations be made by 10 CFR 960.3-1-5?) require geochemical information provided by this study for their resolution. Specifically, this Study and the closely-related Study of Alteration History (SCP 8.3.1.3.2.2.1) will provide data to evaluate the following favorable conditions:

1. The nature and rates of geochemical processes operating in the Quaternary Period, when projected, would not affect or would favorably affect the ability of the geologic repository to isolate the waste.

2. Geochemical conditions that promote precipitation or sorption of radionuclides.

3. Mineral assemblages that, when subjected to the anticipated thermal loading, will remain unaltered or alter to mineral assemblages having equal or increased capacity to inhibit radionuclide migration.

Potentially adverse conditions will be evaluated by identifying geochemical processes that would reduce sorption of radionuclides, result in the degradation of rock strength, or adversely affect the performance of the engineered barrier.

The data gathered under this Study Plan will be used in conjunction with sorption data (SCP 8.3.1.3) to calculate chemical retardation factors for each species of radionuclides. Chemical retardation factors are required performance parameters for assessing the following performance allocation scenarios: 1) the nominal case for release of radionuclides, 2) failure of unsaturated zone barriers, and 3) failure of saturated zone barriers (SCP Tables 8.3.5.13-8 and -9). The sorptive behavior of radionuclides in tuffs is largely controlled by the mineralogy, petrology, and chemistry of the rocks. Only a limited number of sorption experiments can be conducted on tuffs in the time available before license application; these experiments will characterize the average sorptive behavior for each radionuclide as a function of whole-rock mineralogy and chemistry. Sorptive retardation factors will be calculated for potential groundwater transport pathways by using the mineralogic, petrologic, and chemical data in this Study as a framework for extrapolating the results of sorption experiments performed with a limited number of samples to a three-dimensional distribution of sorption behavior across the site (activity 8.3.1.3.7.1.2; geochemical/geophysical model of Yucca Mountain and integrated geochemical transport calculations).

Data gathered under this Study Plan will also support other SCP investigations, studies, and activities. Application of the results of this Study are described in Section 4.0 of this Study Plan.

This Study is based on examination of samples from the drill holes (SCP 8.4.2.2), samples from outcrops, and samples from the Exploratory Shaft Facility. Section 2.4 of this Study Plan gives general guidelines about the locations of drill holes to be studied and the numbers of samples to be collected. However, we intend our sampling plan to be an iterative process with data collected from early drill holes providing a basis for modifying and improving drilling and sampling plans for later drill holes. The statistical techniques that will be used to evaluate the adequacy of drill hole and sample data are described in Section 3.5 of this Study Plan. The number of samples will also vary among the various analytical methods employed (e.g., x-ray diffraction, electron microprobe, x-ray

fluorescence); our goal is to provide a statistically-valid data base for each of the analytical methods used.

2. RATIONALE

2.1 Approach

This Study will examine the mineralogic and chemical variability of rocks in the unsaturated and saturated zones with particular emphasis placed on the repository host rock and on those units occurring along potential groundwater paths to the accessible environment. To accomplish this task, we have reorganized the activities presented in the SCP into the activities shown in Table I. These activities were reorganized for the purposes of this Study Plan so that suites of samples that will undergo similar types of analyses are grouped together. For example, all samples examined under the activity "Internal Stratigraphy of the Candidate Host Rock" will be subjected to modal analysis by optical microscope techniques. Samples examined under the section "Quantitative Mineralogy of the Host Rock and Underlying Rocks along Transport Pathways" will be analyzed by x-ray diffraction. Brief descriptions of the activities in this Study are as follows:

- Quantitative Mineralogy of the Host Rock and Underlying Rocks Along Transport Pathways. The purpose of this activity is to determine the abundance and distribution of minerals occurring in the fractures and matrix of the host rock and in deeper stratigraphic units along potential groundwater flow paths from the repository to the accessible environment (SCP Sections 8.3.1.3.2.1.1, 8.3.1.3.2.1.2 and 8.3.1.3.2.1.3).

- Internal Stratigraphy for the Candidate Host Rock. This activity will define mappable stratigraphic subdivisions within the Topopah Spring Member based on vertical and lateral variations of microscopic groundmass textures, modal phenocryst abundances, mineralogy, and mineral chemistry (SCP 8.3.1.3.2.1.1).

- Chemical Variability in the Host Rock and Along Transport Pathways. This part of the Study examines chemical variations in the candidate host rock and in rocks and radionuclide-sorbing minerals along transport pathways. These data will support all three activities in SCP Sections 8.3.1.3.2.1.1 and 8.3.1.3.2.1.2.

- Role of Fractures and Faults as Past Transport Pathways and Evidence for Paleo-water Table(s). This activity includes textural relationships, chemistry, and relative ages of fracture-lining minerals to determine past transport pathways, depositional conditions, and maximum elevations of paleo-water table(s) (SCP Section 8.3.1.3.2.1.3).

- Statistical Evaluation of Mineralogic, Petrographic, and Chemical Data. This part of the Study is a statistical analysis of mineralogic, petrographic, and chemical data from Yucca Mountain to establish levels of confidence at which data can be extrapolated between widely spaced drill holes (SCP Sections 8.3.1.3.2.1.1 and 8.3.1.3.2.1.2).

These activities, when used in conjunction with results from sorption experiments (SCP activity 8.3.1.3), directly support performance assessment by providing the chemical and mineralogic framework for assigning sorption retardation factors to rock units at Yucca Mountain. Because of the known variations in the chemistry and mineralogy of rocks, sorption retardation factors are expected to vary as a function of vertical and lateral position beneath the site.

TABLE I. CORRELATION OF ACTIVITIES IN THIS STUDY TO ACTIVITIES IN THE SITE CHARACTERIZATION PLAN

Study Plan Activity	Site Characterization Plan Activity	
Quantitative Mineralogy of the Host Rock Along Transport Pathways	8.3.1.3.2.1.1	Petrologic Stratigraphy of the Topopah Spring Member
	8.3.1.3.2.1.2	Mineral Distributions Between the Host Rock and Accessible Environment
	8.3.1.3.2.1.3	Fracture Mineralogy
Internal Stratigraphy for the Candidate Host Rock	8.3.1.3.2.1.1	Petrologic Stratigraphy of the Topopah Spring Member
Chemical Variability in the Host Rock Along Transport Pathways	8.3.1.3.2.1.1	Petrologic Stratigraphy of the Topopah Spring Member
	8.3.1.3.2.1.2	Mineral Distributions Between the Host Rock and Accessible Environment
Role of Fractures and Faults as Past Transport Pathways and Evidence for Paleo-Water Tables	8.3.1.3.2.1.3	Fracture Mineralogy
Statistical Evaluation of Mineralogic, Petrographic, and Chemical Data	8.3.1.3.2.1.1	Petrologic Stratigraphy of the Topopah Spring Member
	8.3.1.3.2.1.2	Mineral Distributions Between the Host Rock and Accessible Environment

These activities also support the activity "History of Mineralogic and Geochemical Alteration at Yucca Mountain" (SCP Section 8.3.1.3.2.2.1) by providing the mineralogic and chemical data that describe the present-day alteration mineral assemblages at Yucca Mountain. The temperature and chemical conditions under which these mineral assemblages formed can be constrained by the mineral species present, their chemistry, their abundances, their textures, and their distribution.

2.2 Types of Measurements and Determinations to be Made

The measurements and determinations that will be made include:

- mineral identifications, abundances, and distributions in bulk rocks and fractures by x-ray diffraction,
- major, minor, and trace element chemistry of whole rocks, mineral separates, and fracture coatings by x-ray fluorescence, atomic absorption spectrophotometry, and neutron activation analysis,
- mineral chemistry by electron microprobe analysis,
- groundmass textural variations by modal petrography, and
- textural relationships of minerals in fractures by scanning electron microscope.

Analytical methods to be used for each activity are discussed in the appropriate methods sections under that activity. Not all methods will be used for each sample.

2.3 Rationale for Choosing Types of Measurements Made

X-ray diffraction (XRD) provides an unambiguous identification of mineral phases present at levels above detection limits and gives a quantitative estimate of mineral abundances. In cases where mineral identifications are ambiguous because abundances are close to detection limits, additional methods such as optical petrography and electron microprobe analysis can be used to complement XRD analyses. XRD is the only technique suitable for determinations of mineral species and abundances, particularly for the fine-grained groundmass and fracture-lining minerals that are of interest to the Project.

X-ray fluorescence (XRF) is one of several techniques available for determining major-, minor-, and trace-element concentrations in bulk-rock samples. The suite of elements to be analyzed by XRF includes SiO_2, TiO_2, Al_2O_3, FeO (total), CaO, MgO, Na_2O, K_2O, MnO, P_2O_5, Ba, Rb, Sr, V, Cr, Ni, Zn, Y, Zr, and Nb. We have chosen XRF over other techniques such as emission spectroscopy and atomic absorption spectroscopy because, although all of the methods have acceptable levels of accuracy and precision, XRF analyses are rapid and samples are readily archived. Neutron-activation analysis (NAA) will be used for additional major-, minor and trace-element analysis (Na, Mg, Al, Cl, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Cu, Zn, Ga, As, Se, Br, Rb, Sr, Zr, Mo, Ag, In, Sb, I, Cs, Ba, La, Ce, Nd, Sm, Eu, Tb, Dy, Yb, Lu, Hf, Ta, W, Au, Hg, and Th. Uranium concentrations will be determined by delayed neutron counting. NAA is a nondestructive, sensitive, and precise analytical method that complements the analytical suite done by XRF, particularly for trace elements. Fluorine and chlorine will be determined by atomic absorption spectrophotometry, a method that is both sensitive and cost-effective. The applications of these data are described in Section 3.3 of this Study Plan.

Electron microprobe analysis is the only practical technique for determining compositions of primary and secondary minerals in the groundmass and fractures. The electron beam can be focused on areas ranging from 1-25 microns square, and therefore quantitative compositions can be determined for most minerals. Other techniques, such as liquid separation of individual phases or analysis by standard bulk-rock techniques, are not cost-effective and offer no substantial improvement in precision and accuracy for major chemical components.

Modal petrography by optical microscopy complements the data collected by the techniques described above by allowing investigators to determine the distribution and textural relations of fracture and groundmass minerals. Microscopy is also useful in choosing samples for bulk-rock chemical analyses and for determining suitable mineral grains for electron microprobe analysis. We are investigating the use of image analysis as a technique for quantifying groundmass textures; however, this analysis is not fully developed at the present time.

Scanning electron microscope (SEM) inspection of samples, particularly open fractures, allows determination of textural relations at a much finer scale than can be achieved by either binocular microscope (open fractures) or petrographic microscope (thin sections of closed fractures). Qualitative chemical analyses useful for mineral identification can be made on grains that are too small for quantitative electron microprobe analysis or on open fracture surfaces that cannot be studied in thin sections.

2.4 Sampling

An important goal of this Study is to characterize accurately and completely the rocks along potential transport pathways; our ability to define the mineralogy and chemistry along pathways is directly linked to our knowledge of the locations of these pathways. The extent of this knowledge is a significant constraint on this Study. We are therefore attempting to obtain a knowledge of the vertical and lateral variations in mineralogy and chemistry along all likely groundwater flow paths between the host rock and the accessible environment so that our results are not significantly limited by our ability to define flow paths. Thus, this constraint will require numerous analyses of rocks and minerals within the controlled area boundary (Fig. 2).

2.4.1 Location of Drill Holes

Samples collected from surface-based drill holes will allow us to evaluate the lateral changes in mineralogy, chemistry, and petrography at Yucca Mountain by providing an areally extensive suite of subsurface samples from the exploration block (Fig. 1) and the surrounding controlled area (Fig. 2). The sampling program for the unsaturated zone will emphasize characterization of rock units beneath the exploration block, particularly between the candidate host rock and the water table. Characterization of the saturated zone requires that samples be collected beneath the exploration block and along potential groundwater flow paths to the accessible environment; emphasis will be placed on characterizing down-gradient groundwater flow paths to the south and east.

Drilling activities providing samples for this study include the systematic drilling program (SCP 8.3.1.4.3.1.1), geologic (G) core holes (SCP 8.3.1.4.2.1.1), unsaturated zone (UZ) drill holes (SCP 8.3.1.2.2.3.2), and water-table (WT) holes (SCP 8.3.1.2.3.1.2). Additional descriptions of these drill holes can be found in section 8.4.2.2 of the SCP. Most of the samples supporting this Study will come from the systematic drilling program.

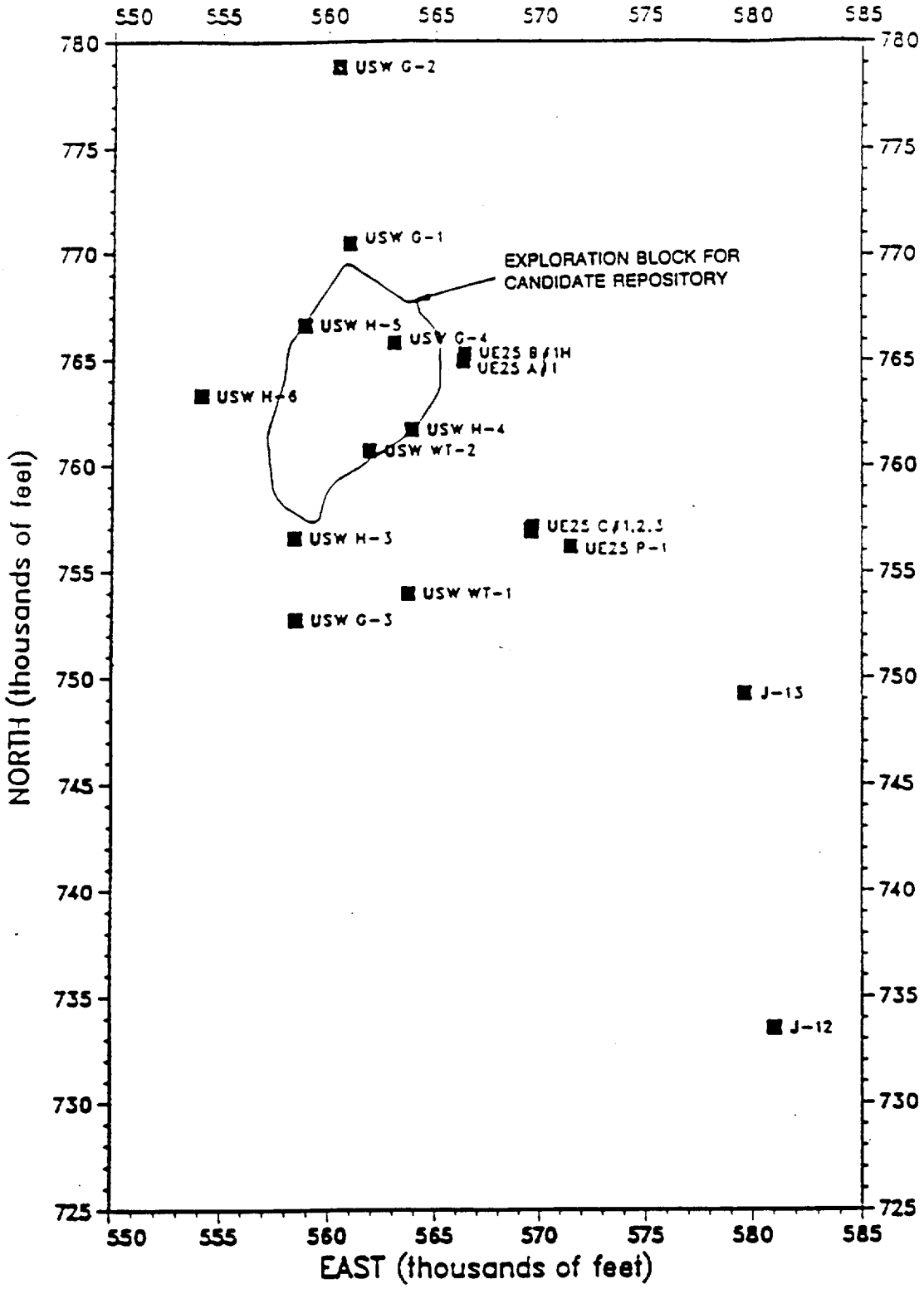


Figure 1. Location map of existing drill holes used in this study.

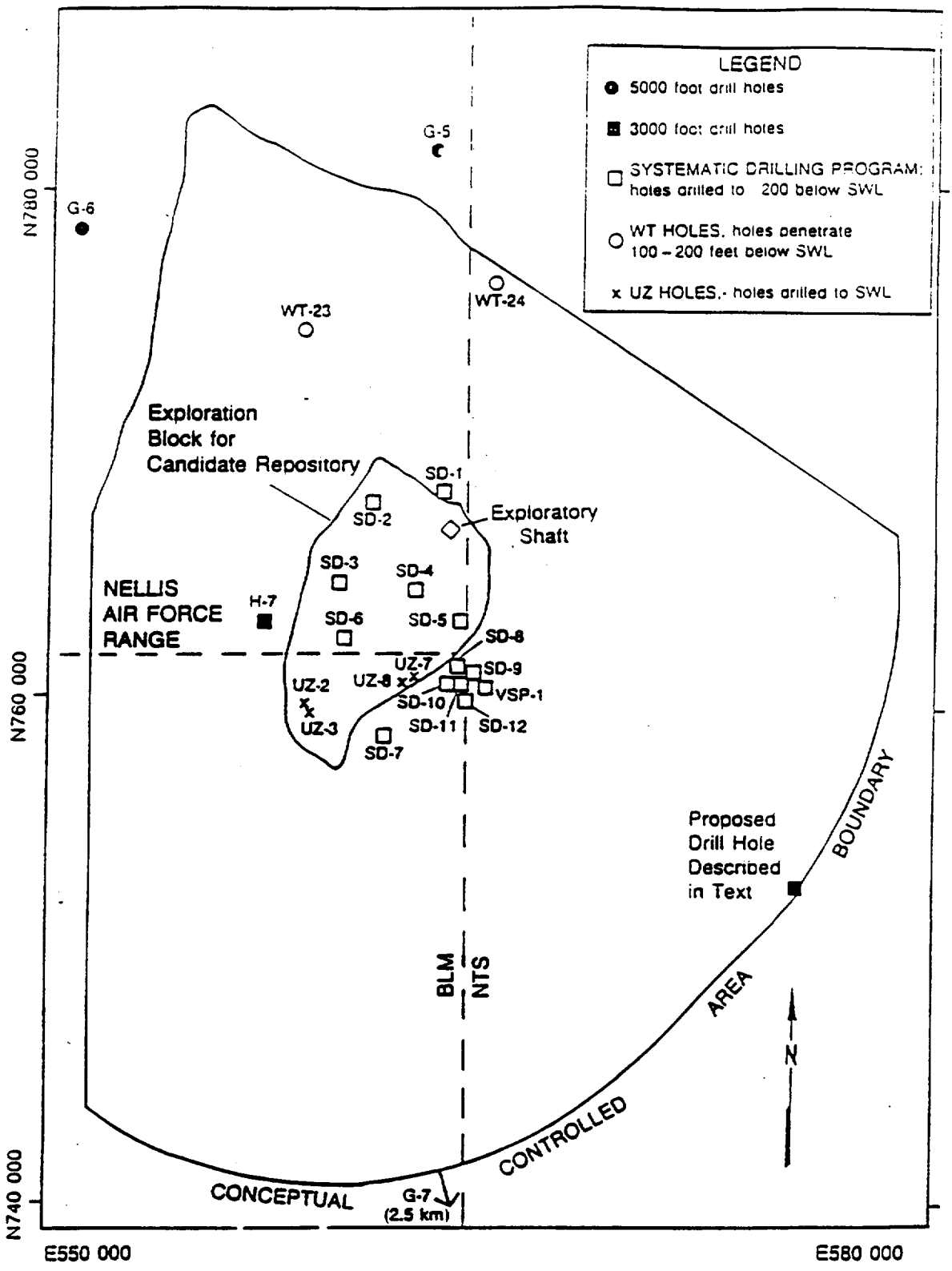


Figure 2. Drill holes that will provide samples for this study.

The systematic drilling program at Yucca Mountain (SCP 8.3.1.4.3.1.1) will take place in two discrete phases. During the first phase, holes will be distributed at various spacings to assess the effects of drill hole density on the extrapolation of geologic information across the exploration block. Section 3.5 of this Study Plan describes the extrapolation techniques that will be applied to mineralogic, chemical, and petrographic data. The second-phase drilling will be designed to complete the characterization of the exploration block and of potential groundwater pathways to the accessible environment. The optimization of drill hole densities during the second phase will take place under SCP activity 8.3.1.4.3.1.1 and will depend on 1) the intrinsic variability of rock units at the site, 2) the sensitivity of radionuclide transport models to uncertainties in characterizing these parameters, and 3) an economic cost analysis for completing the drilling program.

Analyses have been already performed on core and cuttings from holes drilled for early investigations; therefore, the distribution of the holes was determined by those investigations. The location of these existing holes is shown in Figure 1.

The drilling program planned for site characterization will allow improved accuracy in a predictive model of mineralogy and chemistry across the candidate repository block and out to the accessible environment. For purposes of characterization of potential transport pathways, the holes used need to be fully cored and extend to the first major laterally transmissive zone below the water table. As this has not been well defined as yet, our working boundary for characterization is the base of the Crater Flat Tuff and its underlying flow breccia in the northern part of the exploration block. This choice is based on hydrologic data showing several transmissive zones in the Crater Flat Tuff in most holes (Benson et al., 1983; Lobmeyer, 1986). Three drill holes (USW G-5, USW G-6, and USW G-7) are planned that will penetrate the older volcanic units beneath the Crater Flat Tuff and its underlying flow breccia. We plan to characterize the mineralogy, chemistry, and petrography of these units where these units are penetrated.

Our requirements for deep drill holes (approximately 3000 feet total depth) are not incorporated into the present version of the SCP. These requirments will be addressed in the next SCP update.

The drill holes that we plan to use in this Study for site characterization are shown in Figure 2. In addition, a hole to be located between J-13 and UE-25p#1 (approximate location shown by an open box in Figure 2) would provide important information on mineralogic and chemical variability along saturated flow paths and on the Topopah Spring Member under saturated conditions. The locations of drill holes proposed for this Study may change as the drilling program for surface-based testing changes. Samples from the ES and drifts will provide information on the Paintbrush Tuff and will be used extensively in activity 8.3.1.3.2.1.1 of the SCP (Petrologic Stratigraphy of the Topopah Spring Member). Outcrop samples may also be used in the activity. Cuttings from additional hydrology holes may be used to provide supplemental data for this Study if needed. The locations of outcrop and drill cuttings samples will be determined as the requirements are developed for these types of samples.

2.4.2 Sample Distribution Within Drill Holes

Sampling along a drill core is done in such a way as to assure that each lithologic unit and each fracture coating type is sampled. The results of prototype testing will be used to determine sample sizes and sample densities to be used during site characterization. We anticipate a maximum sampling interval of approximately 50 ft, but samples may be taken more frequently as required for adequate characterization of the core. The sample locations will be determined by the investigator after inspection of the core; geological logs provided by the U.S. Geological Survey (USGS) will

provide information to guide sample selection. During the first phase of the systematic drilling program, we anticipate collecting approximately 1000 samples to characterize the mineralogy of whole rock samples. Splits of about 150 of these mineralogic samples will be analyzed for major- and trace-element chemistry. Petrographic thin sections will be prepared for all of the mineralogic samples; mineral-chemical data will be collected for secondary minerals in approximately 100 of the thin sections. Approximately 800 samples will be collected to characterize the fracture mineralogy of the site during first-phase drilling. The number and distribution of samples collected during the second phase of the systematic drilling program will be determined after the results of first-phase drilling have been evaluated.

2.4.3 Statistical Analysis of Sample Distribution

The question of the number and spacing of samples required to characterize adequately the rocks and minerals along groundwater transport pathways at Yucca Mountain is addressed by the activity described in Section 3.5 of this Study Plan. Additional holes cannot provide additional reliability of a calculational model for predicting releases to the accessible environment (SCP 8.3.5.13.3) if the small-scale variability (measured in many cores by the within-hole variance of the observations) is not significantly smaller than the variability between holes drilled at the maximum feasible density. A preliminary study by Campbell (1988), kriging existing XRD data using a technique described in Section 3.5.1 of this Study Plan, strongly suggests that local variability of mineralogy may be substantial. However, this analysis used data which are not of QA Level I, and many more such computations using data from the holes proposed above will be made before the adequacy of this sampling plan can be assessed. If, when data collection is completed on the holes proposed during the first phase of the systematic drilling program, greater accuracy in the predictive model is found to be both attainable and also needed to satisfy requirements for licensing, additional data collection in the existing drill holes will be proposed. If the distribution of the first-phase drill holes provides inadequate characterization of the site, additional drill holes will be proposed (second phase) to provide the necessary information.

Existing fracture-mineral data are not as complete as rock matrix data, and core from several drill-holes shown in Figure 1 must be examined before the distribution of fracture coatings can be determined and any statistical methods employed to determine the number and spacing of samples required to develop a predictive model for Yucca Mountain.

2.5 Additional Factors for Consideration

2.5.1 Impact on Site

The analyses necessary for this Study should have minimal impact on the site because most samples necessary for the Study will be obtained from cores from existing and planned drill holes or from surface outcrops. Much of the data on the internal stratigraphy of the candidate host rock and on the mineralogy of fractures and faults will be acquired using samples from the exploratory shaft. Sampling procedures for the exploratory shaft samples are being developed as part of the prototype test plan and are not part of this Study Plan.

2.5.2 Required Accuracy and Precision and Limits of Methods

Results from this Study will provide an understanding of the vertical and lateral variability of the mineralogy and chemistry of rocks at and in the vicinity of Yucca Mountain. Data with known and predictable error will provide estimates and bounds on effective mineralogy used in calculating overall retardation by sorption and will provide stratigraphic control during repository construction. This Study will provide highly accurate determinations of the presence or absence of phases in the rocks and fractures. The detection limits, accuracy and precision of x-ray diffraction, x-ray fluorescence, microprobe, and petrographic analyses are sufficient for the needs of this study; techniques are described in detail by Bish and Chipera (1986), Broxton et al. (1986), and Byers and Moc - 1987).

Statistical studies will address the uncertainties associated with sample inhomogeneity, density, and distribution. The prototype test for sample collection procedures (WBS 1.2.6.9.4.1.3) will examine inhomogeneities in the candidate host rock on the microscopic, hand-specimen, and outcrop scale. In addition, statistical methods for interpolating data between widely spaced and unevenly distributed drill holes are being developed under Section 3.5 of this study plan. All of the above studies will be used to determine uncertainties associated with sample collection. Sampling procedures for fracture studies will be developed in the prototype test for sample collection procedures (WBS 1.2.6.9.4.1.3).

Accuracies and precisions for individual analytical methods are given in sections 3.1.2, 3.2.2, and 3.3.2 of this Study Plan.

2.5.3 Capability of Methods to Support Study

The techniques employed in this Study are standard techniques with known reliabilities. The methods used for analyzing the data are also standard for the most part. Minor variations in the analytical procedures are described in Sections 3.1, 3.1.2, 3.3.1, and 3.4.1. The techniques are sufficient for the requirements of this Study.

2.5.4 Time Required Versus Time Available

We anticipate that this Study will be completed in time to support the license application given existing schedules for the exploratory shaft and integrated drilling program.

2.5.5 Interference with Other Studies

This Study is not expected to interfere with any other studies or tests.

2.5.6 Quality Assurance Requirements

The activities in this Study Plan have been assigned as Quality Level I in accordance with paragraph 5.2.1d in procedure TWS-MSTQA-QP-18. These data may be used in assessing radionuclide migration which hss a direct bearing on site assessments concerning waste isolation to be used in the license application. The criteria from NQA-1 that apply to this study are shown in Appendix A and the procedures that will satisfy these criteria are shown in Appendix A and in sections 3.1.1, 3.2.1, 3.3.1, and 3.4.1 of this Study Plan. The Quality Level Assignment Sheets for this Study are included in Appendix A.

The software used to support licensing will be verified and validated according to the LANL Software QA plan.

3. DESCRIPTION OF MEASUREMENTS AND ANALYSES

The following description of measurements and analyses contains a more detailed discussion of work being performed in support of Investigation 8.3.1.3.2.1 of the SCP. Section 2.1 of this Study Plan shows how each of the following sections relates to activities in the SCP.

3.1 Quantitative Mineralogy of the Host Rock and Along Transport Pathways

The quantitative mineralogy of the host rock and of the rock matrix along transport pathways at Yucca Mountain will be determined by analyzing core, outcrop, and exploratory shaft material using x-ray powder diffraction.

These analyses will be performed on homogenized powdered samples and will provide accurate and unambiguous determination of the phases present. The use of standards of all the minerals present in the tuffs plus a corundum internal standard permits determination of the amounts of all phases present. X-ray diffraction patterns of samples with a corundum internal standard will be recorded for all whole-rock samples analyzed. Analyses will be performed on samples from core and from the exploratory shaft samples whenever changes in lithology are apparent so that complete mineralogical data are available for all lithologies.

The mineralogy of fracture- and fault-lining minerals will be determined by analyzing scraped samples of fracture coatings. Whenever sufficient material is available, quantitative analysis will be performed as for whole rock samples. Because many fractures have thin and/or discontinuous coatings, it is not always possible to obtain enough sample for an XRD powder with an internal standard; in these cases semi-quantitative analyses must be performed on smear samples with an external standard. The purpose of the analyses is mineral identification, thus samples will be chosen to provide the thickest covering of representative minerals. Therefore, the relative proportions of minerals in a given sample may not be representative of the actual proportions over a larger area of the fracture. Once mineral identifications are established, visual estimates of fracture-surface coverage will be made for each mineral phase. These estimates will be compared to the semi-quantitative XRD results.

Fibrous zeolites in the host rock matrix and fractures will be identified and quantified to allow assessment of possible health risks to workers inhaling dust containing these minerals during construction of the repository. Study of fibrous minerals supports SCP Study 8.3.1.15.1.8, which is examining constraints on the ventilation of the underground repository facilities imposed by such minerals.

3.1.1 Methods

Analyses will be performed on powdered samples using x-ray powder diffraction. The methods to prepare samples and to perform quantitative analysis of rocks using x-ray powder diffraction data are those described by Bish and Chipera (1986) and in the procedures listed below. Additional methods for data analysis may employ fitting of the whole diffraction pattern (Bish and Howard, 1987) and simultaneous linear equations methods combining x-ray diffraction data with x-ray fluorescence chemical analyses. If needed, these procedures will be developed 30-60 days before their use in tests. The only modification anticipated in our sample preparation procedure may be the eventual addition of a spray dryer to prepare samples with little or no preferred orientation. This modification is dependent upon the development in industry of a suitable spray dryer. The methods used to prepare and analyze smear samples of fracture minerals are described in Carlos (1987).

These analyses will provide data used in predicting the long-term performance of the site and, as such, are classified as Quality Level I. The work will be performed in accordance with the Los Alamos National Laboratory (LANL) Quality Assurance Program Plan for the Yucca Mountain Project. The following technical procedures will also apply:

1. Siemens X-Ray Diffraction Procedure, TWS-ESS-DP-16.
2. Clay Mineral Separation and Preparation for X-Ray Diffraction Analysis, TWS-ESS-DP-25.
3. Nevada Test Site Fracture-Filling Studies Procedure, TWS-ESS-DP-28.
4. Pulverizing, Using the SPEX 8500 Shatterbox, TWS-ESS-DP-53.
5. Crushing, Operating of 50-Ton Hydraulic Press, TWS-ESS-DP-54.
6. Rock Splitting, Operating of 50-Ton Hydraulic Press, TWS-ESS-DP-55.
7. Brinkman Automated Grinder Procedure, TWS-ESS-DP-56.
8. Quantitative Analysis by X-Ray Powder Diffraction, TWS-ESS-DP-116.
9. X-Ray Fluorescence Weighing Procedure, TWS-ESS-DP-51.
10. Fusing, Using the Junior Orbit Shaker, TWS-ESS-DP-52.
11. Procedure for X-Ray Fluorescence Analysis, TWS-ESS-DP-111.

3.1.2 Required Accuracy and Precision

This activity requires high accuracy in identification of minerals present in tuffs, but high precision on individual amounts is not required for most minerals. X-ray powder diffraction routinely provides unambiguous qualitative determinations of the presence or absence of minerals in tuffs above the minimum detection limits. Detection limits are a function of what mineral is being determined and of experimental conditions but are generally 1-5% of the rock. Precision of determinations of individual minerals in pressed powder samples is a function of the mineral being determined. Future advances in data reduction should improve precisions to at least ±5% of the determined amount for bulk samples. At present, precision in oriented smear samples used in fracture studies is probably no better than ±25% of the determined amount. That number will be improved somewhat by use of similarly prepared standards in the data reduction, but the primary purpose of the analysis of fracture coatings remains identification of minerals in fractures, not quantification of amount. We expect ranges in mineralogical compositions similar to those reported in Bish and Chipera (1986) for bulk-rock samples and similar to those reported by Carlos (1985, 1987) for fracture minerals.

The accuracy of input required for transport modeling has not been determined yet, therefore the accuracy of results needed in this activity cannot be defined. For use in modeling functional stratigraphy, we have set as our limit of accuracy in predicting zeolitic versus nonzeolitic as 20 m, which is 10% of the average thickness of the Calico Hills Tuff. A tuff is considered to be zeolitic if it contains more than 20% zeolites.

3.1.3 Equipment Required

Most equipment required for this activity is presently available at Los Alamos, including equipment used for sample preparation (rock crusher, shatterbox, and automated grinder) and analytical equipment, such as the Siemens D-500 x-ray diffractometer and the Rigaku x-ray fluorescence spectrometer. All computer hardware necessary for data reduction is also available. When available on the market, an appropriate spray dryer will be purchased for use in eliminating preferred orientation effects in x-ray powder diffraction analyses.

3.1.4 Data Reduction and Analysis

The program QUANT5 will be used initially to reduce all intensity data obtained on the Siemens x-ray diffractometer to determine weight percents of individual minerals. QUANT5 performs either internal or external standard analyses using standard data collected on the Siemens diffractometer. Integrated intensity data used as input to QUANT5 will be obtained using software provided with the Siemens diffractometer. X-ray fluorescence data will be reduced using the program XRF-11 written by Criss Software, Largo, MD. Future enhancements in XRD data reduction may incorporate Rietveld methods and/or simultaneous linear equation methods coupled with XRF chemical data.

QUANT5 and XRF-11 will be documented, used, and controlled in accordance with the LANL YMP procedure for configuration management (TWS-QAS-QP-3.11) and the procedures for software control (TWS-QAS-QP-3.12 and QP-3.13).

3.1.5 Representativeness of the Tests and Limitations and Uncertainties

Prototype tests for the collection of samples are presently underway to address the representativeness of core, shaft, and outcrop samples. The results of these prototype tests will be used to guide the methodologies for collection of samples in this Study. These analyses will provide representative data to the extent that the analyzed core is representative of the rock and fractures being studied. Approximately 1000 whole-rock samples and 800 fracture-filling samples will be analyzed from core holes, drill holes, and the exploratory shaft and drifts during the first phase of the drilling program. Typically we are able to collect, analyze, and report whole-rock data for a 6,000-ft drill hole in one man-year. Sampling densities vary according to the lithologic complexity of the rock units, but in the past we have collected approximately one sample/50 ft of lithologically uniform drill core. This density may change in future work based upon the results of ongoing statistical studies (Section 3.5 and WBS 1.2.6.9.4.1.3).

Fracture minerals are nonuniformly distributed in drill cores. Based on past experience with Yucca Mountain cores, we expect to collect an average of four fracture coatings per 100 feet of core. Actual sample densities will vary depending on fracture frequencies with different stratigraphic intervals. Ultimately, sample densities will be determined by the principal investigator after examination of the core. Collection, analysis, and reporting of fracture-mineral data for a 6,000-ft drill hole generally takes 1.5-2 man-years.

Data for core, shaft, and outcrop samples collected over a large area will be used to determine the vertical and lateral variability of minerals at Yucca Mountain. The use of these data will be limited by the number of samples that can be analyzed and by the frequency of sampling. For example, the more samples analyzed from a given area, the better our knowledge will be for that area. As outlined above, our ability to define the mineralogy along potential groundwater pathways from the

repository to the accessible environment will ultimately be limited by our ability to predict the locations of these pathways, not by our ability to obtain mineralogic data for the site.

3.2 Internal Stratigraphy for the Candidate Host Rock

The Topopah Spring Member consists of a thick layer of rhyolitic rock overlain by a relatively thin quartz latite caprock (Lipman et al., 1966). The potential repository workings will be within the rhyolitic portion of the Topopah Spring Member, which is homogeneous in chemical composition (Lipman et al., 1966; Zielinski, 1983) but is variable in textural and phenocryst petrography (Byers, 1985; Byers and Moore, 1987) and in mineralogy (Bish and Vaniman, 1985).

Petrographic data from drill cores show that textural features can be used to determine stratigraphic position to within 50-100 ft within the densely-welded interior of the Topopah Spring Member. There are four major stratigraphic subdivisions between the quartz latitic caprock and basal vitrophyre of the Topopah Spring Member. These subdivisions, which define the internal stratigraphy of the Member, include in ascending order: 1) the lower nonlithophysal zone, 2) the lower lithophysal zone, 3) the middle nonlithophysal zone, and 4) the upper nonlithophysal zone. Petrographic studies have been important in developing the internal stratigraphy of the Topopah Spring Member in the vicinity of the exploration block (Byers and Moore, 1987). Petrographic studies will be extended to new drill core, to shaft samples, and to outcrop samples to refine stratigraphic subdivisions within the tuff.

We will also examine the feasibility of computerized image analysis of thin sections to determine if this new technique has potential for quantifying the amounts of some textural features such as spherulitic/microlitic groundmass, granophyre, cryptocrystalline groundmass, amygdules, and phenocrysts that are now measured by point-counting methods. If image analysis studies are successful, the results will be compared to observations from petrographic studies. We are also considering the feasibility of image analysis to examine large-scale welding and crystallization features in rock slabs; rock staining techniques may be used to enhance the discrimination of these features.

3.2.1 Methods

Samples will be collected from outcrop, drill core, or underground workings by procedures developed from the prototype test for sample collection for the exploratory shaft (WBS 1.2.6.9.4.1.3). Outcrop or underground samples from a massive solid exposure of Topopah Spring rhyolite will consist of oriented samples with the top, a north arrow and a horizontal plane marked with indelible felt-tip pen. For core samples, thin sections will be cut with the long dimension of the slide vertical and with the down direction marked on the slide in accordance with QA procedure TWS-ESS-DP-04. Muck samples are not oriented.

These thin sections will be point counted to determine percentages of the different grain-size groundmass textures and phenocrysts in order to estimate the stratigraphic position as described in Byers (1985). For this examination the thin sections will be counted in transmitted light, using a research polarizing microscope and an automated point counter. Results will be tabulated and shown graphically in a manner similar to Figure 2 of Byers (1985) and similar to Figures 2 through 5 of Byers and Moore (1987).

The following procedures will be used in sampling, thin-sectioning, and modal counting of textures and phenocrysts in thin section:

1. Sample Identification and Control for Mineralogy-Petrology Studies, TWS- ESS-DP-101.

2. Nevada Test Site Core Petrography Procedure, TWS-ESS-DP-03.

3. Thin Section Preparation Procedure, TWS-ESS-DP-04.

4. Procedure for Determination of Volume Percent of Constituents in Thin Sections of Topopah Spring Member and Similar Rhyolites, TWS-ESS-DP- 102.

3.2.2 Required Accuracy and Precision

Petrographic modal analyses generate quantitative phenocryst mineral percentages. Doubtful identifications of microphenocrysts in a fine-grained volcanic rock can be resolved by the electron microprobe when necessary. For most petrographic work, an occasional misidentified microphenocryst (<0.2 mm) would not significantly affect the overall percentages. Modal analyses of textures, however, are at best only semi-quantitative and more prone to operator variance. It remains to be determined whether image analysis can quantify textures and thus increase the speed, efficiency, and reproducibility of this method.

To be useful in determining stratigraphic intervals during construction of a repository, it is necessary to be able to identify a sample to within 25 m of its stratigraphic position. A resolution of 25 m should provide enough control to ensure that the closest approach of the repository to the underlying basal vitrophyre of the Topopah Spring Member is no less than 50 m. It is desirable to keep the minimum separation between the repository and the vitrophyre at least 50 m because of potential thermal stability problems arising in secondary minerals associated with the vitrophyre at temperatures above 100°C. To minimize alteration of glass and secondary minerals in the vitrophyre, the closest desired approach of the repository to the vitrophyre is 50 m (based on temperature profiles developed in Sinnock et al., 1984).

3.2.3 Equipment Required

All necessary standard field equipment for surface-outcrop sampling involving measured sections of the Topopah Spring is available at LANL. This equipment includes a Polaroid camera, 35-mm camera, rock picks, sledge hammers, cold chisels, steel tapes, Jacob staff (measuring pole), Abney level, Brunton compasses, tally recorder, and rock marking and sample bagging supplies. Similar equipment would also be used for underground sampling. Drill core will be marked for sampling; current procedures require that core library personnel take core samples.

Required laboratory equipment includes that in the LANL thin-section laboratory (TWS-ESS-DP-04): a polarizing microscope, an electrically driven automated point counter, and a computerized image analyzer.

3.2.4 Data Reduction and Analysis

The data will be stored in a computer data base, and standard graphic packages will be used for producing binary and ternary phenocryst plots, histograms, and bar graphs plotted with respect to stratigraphic position (Byers, 1985). The data will also be subjected to discriminant statistical analyses (Byers and Moore, 1987). The amount of variance arising from one petrographer making multiple point counts on one thin section and from two petrographers counting the same thin section

will also be assessed. This operator variance test will help us determine what levels of variance are acceptable for this activity.

3.2.5 Representativeness of the Analyses and Limitations and Uncertainties

The analyses will generate data that will be representative of the internal stratigraphy of the Topopah Spring Member. A 20- x 30-mm thin section contains 5,000-12,000 modal point counts in which phenocrysts and textures are identified (Byers, 1985; LANL Procedure TWS-ESS-DP-102). Assuming all material under the cross hairs (point counts) is correctly identified and no constituent is less than 2% of the thin section area, the thin section is representative of the specimen and probably of the adjoining rock. These assumptions about the representativeness of thin sections will be examined in detail during prototype testing. Multiple thin sections will be analyzed where sample representativeness must be demonstrated. The principal source of error in these tests is the consistency between operators in identification of textures.

3.3 Chemical Variability in the Host Rock and Along Transport Pathways

The whole-rock and mineral-chemical data will be used in conjunction with the mineralogic data to characterize the site, providing a basis for correlating sorption and other laboratory tests to the conditions at Yucca Mountain. In addition, the whole-rock and mineral-chemical data will be used to support XRD methods under development (see Section 3.1.1 of this Study). These new XRD methods combine mineralogic data with chemical data to provide constraints on the compositions of individual mineral phases, particularly for those mineral too fine-grained to be analyzed by electron microprobe. Determination of Fe^{2+}/Fe^{3+} will be used to identify rock units that might change the oxidation/reduction potential of groundwaters that come into contact with these rocks. Fluorine and chlorine within the tuffs in the unsaturated zone are incompatible elements that could be concentrated in late stage crystallization products (e.g., vapor phase minerals); these minerals might interact with vadose water to produce weak acids that could have prolonged contact with waste canisters. Mineral-chemical data for zeolites, clays, and manganese oxides will be collected because the sorption potential and mineral stability of these minerals is determined in part by their compositions. Although conditions of analysis are not optimized for many elements of economic interest, many of the chemical analyses (e.g., U, Th, Au) for whole-rock samples will be of sufficient quality for use in the mineral resources evaluation of the site (SCP 8.3.1.9.2). Additionally, the whole-rock chemical data, particularly for trace elements, can contribute to stratigraphic studies of the volcanic units at the site (SCP 8.3.1.4.2.1). The whole-rock chemical data collected in this Study also will be used to support investigations of alteration history of tuffs at Yucca Mountain (SCP 8.3.1.3.2.2.1). Comparison of devitrified, vitric, and zeolitic tuffs will allow us to determine the past mobility of various major-, minor-, and trace-elements during alteration of the tuffs at Yucca Mountain and thus will provide information about expected future alteration.

The chemistry of tuffs and of their matrix minerals will be determined by XRF, NAA, AA, and electron microprobe analysis. Samples will include drill core, outcrop samples, and material from the exploratory shaft. X-ray fluorescence analyses will be used to determine major-, minor-, and some trace-element constituents of whole-rock samples. Samples will be homogenized and fused into glass disks for analysis. We will obtain quantitative chemical analyses by calibrating our sample suite against well-characterized standards with similar chemical compositions. Ferrous iron concentrations will be determined titrametrically; however, we have not yet decided whether these analyses will be determined in-house or contracted to an outside laboratory. Fluorine and chlorine will be determined by atomic absorption spectrophotometry. Neutron activation analysis will be used to determine trace elements not readily detectable by XRF for whole-rock samples. NAA will

also provide independent determination of some major, minor and trace elements determined by XRF.

The chemical compositions of rock-matrix and fracture-lining minerals, including zeolites, clays, secondary feldspars, and manganese- and iron-oxide minerals, will be determined by electron microprobe analyses. Trace element compositions for individual mineral phases can be determined by analyzing mineral separates by XRF and NAA as needed. Microprobe samples will normally consist of polished thin sections. We will use silicate mineral standards to calibrate the electron microprobe during the analyses of silicate minerals; oxide standards will be used when possible to calibrate the electron microprobe during the analysis of oxides. In most cases, we will coordinate the selection of samples for chemical analyses with those collected for XRD so that the mineral chemistry and mineralogy of the alteration assemblages can be compared. When the minerals to be analyzed occur in thin coatings on open fractures, thin sections cannot be made. Minerals on these fracture faces may be analyzed by microprobe using polished epoxy mounts or by analyzing flat fracture surfaces directly.

3.3.1 Methods

Major-, minor-, and trace-element compositions in bulk-rock samples will be determined by XRF. Samples will be prepared by powdering and homogenizing 15-20 g of material in a shatterbox. Duplicate 1- to 2-g sample splits will be heated to 1,000°C for one hour to destroy zeolite and clay crystal structures, thus eliminating gross weighing errors introduced by the rapid rehydration of these minerals upon cooling. Loss on ignition (LOI) in the samples will be determined by the difference in sample weight before and after the heating treatment. The samples will then be ground in an agate grinder and the material prepared for fusion with a fluxing agent. Elemental concentrations will be determined on a Rigaku wavelength-dispersive x-ray fluorescence spectrometer. The spectrometer will be calibrated by running standard reference materials at the time of sample analysis. The standard reference materials, which consist of National Bureau of Standards (NBS), United States Geological Survey (USGS), and other certified rock materials, will be selected to be as similar in composition to the samples as possible. Correction for interelement x-ray matrix effects for major elements are performed by a fundamental parameters method. Matrix corrections for trace elements are made by ratioing the elements' net intensity to the net Rh-Compton intensity.

Because the drying procedure described above results in significant sodium loss in samples with abundant hydrous minerals (Broxton et al., 1986), splits of all samples will be analyzed for sodium by NAA or AA. Other volatile elements such as fluorine and chlorine will be determined by AA. A procedure for AA analyses will be prepared.

Neutron activation analysis will be used to determine major, minor, and trace-element concentrations in whole-rock samples and, if needed, in mineral separates. Approximately 4 g of sample is irradiated in a thermal neutron flux of ~6 X 10^{12} neutrons/cm^2/s at the Los Alamos Omega West research reactor. Uranium concentrations are determined by delayed-neutron counting (DNC). The samples are then entered into the NAA sequence. The full DNC/NAA sequence for each sample is 20-s irradiation, 10-s delay, 30-s DNC analysis, 20-min delay, 475-s gamma-ray count for short-lived radionuclides, 500-s re-irradiation, 4- to 7-day delay, 1-hr gamma-ray count for intermediate-lived radionuclides, 3-wk delay, and finally a 2-hr count for long- lived radionuclides. Gamma-ray counting is done by lead-shielded Ge (Li) detectors. Detectors are set at distances of 40 cm, 5 cm, and on contact, respectively, when short, intermediate, and long counts are done. The

4096-channel gamma-ray data are recorded and subsequently analyzed by computer. Neutron activation procedures are described in detail in Minor et al. (1982).

Mineral and glass compositions will be determined on polished thin sections by an automated Cameca electron microprobe operated at 15 keV and 13- to 20-nA beam currents. Calibration standards for silicate minerals will include feldspars, amphiboles, and pyroxenes. Calibration standards for oxide minerals include oxides, barite, silicate minerals and glass. Wavelength dispersive x-ray counts for major elements will be counted for 15-20 s or less if 10,000 counts are acquired. Minor elements may be counted for as long as 120 s. Sodium will be counted first during analysis because it tends to migrate from the region excited by the electron beam. When analyzing hydrous minerals or glass, we will use as large a rastered beam as possible (5-25 microns on an edge) and, if possible, move the sample beneath the electron beam to minimize the migration of sodium and the dehydration of the sample.

We are developing electron-microprobe methods for the analysis of minerals on open fracture surfaces, on both polished epoxy mounts and natural surfaces.

The following procedures will be used in XRF, NAA, and electron microprobe analyses:

1. Thin Section Preparation Procedure, TWS-ESS-DP-04.
2. Operating Instructions for DV-502 Vacuum Evaporator for Carbon Coating Samples, TWS-ESS-DP-06.
3. Microprobe Operating Procedure, TWS-ESS-DP-07.
4. Nevada Test Site Fracture-Filling Studies Procedure, TWS-ESS-DP-28.
5. X-Ray Fluorescence Weighing Procedure, TWS-ESS-DP-51.
6. Fusing, Using the Junior Orbit Shaker, TWS-ESS-DP-52.
7. Pulverizing, Using the SPEX 8500 Shatterbox, TWS-ESS-DP-53.
8. Crushing, Operating of 50-Ton Hydraulic Press, TWS-ESS-DP-54.
9. Rock Splitting, Operating of 50-Ton Hydraulic Press, TWS-ESS-DP-55.
10. Procedure for X-Ray Fluorescence Analysis, TWS-ESS-DP-111.
11. Procedure for Neutron Activation Analysis, TWS-ESS-DP-117.
12. Procedure for Atomic Absorption Analysis, estimated completion date December, 1989.

3.3.2 Required Accuracy and Precision

Previous work by Los Alamos has shown that the whole-rock and mineral-chemical compositions at Yucca Mountain are variable (Broxton et al., 1986 and 1987). For fracture-lining minerals, the expected ranges of compositions should be similar to those reported in Carlos (1985, 1987), except for Mn-oxides above the water table for which mineral compositions have not yet been published.

These earlier investigations provide estimates for the expected range of compositions of rocks and minerals at Yucca Mountain. Based on these earlier investigations, the analytical errors for XRD, NAA, and microprobe analysis are acceptably small compared to the compositional variations found in the rocks and minerals.

XRF analyses generally have relative precisions of better than 5% for major chemical constituents and 20% for minor and trace constituents. These errors can exceed 100% as detection limits are approached. For microprobe analyses, minimum detection limits and errors in calculated weight percents are determined for each analysis from counting statistics. In general, precisions for microprobe analyses are similar to those for XRF. Neutron activation analysis typically has relative errors of 10% or less when elemental concentrations are one order of magnitude above the detection limits (Garcia et al., 1982).

3.3.3 Equipment Required

All of the equipment required for this activity is presently available. Complete laboratories are available for splitting and homogenizing rock samples; for fusing glass disks for XRF studies; and for cutting and polishing thin sections for electron microprobe studies. Analytical hardware such as the Rigaku x-ray fluorescence spectrometer and Cameca automated electron microprobe are available for use. Facilities are also available for irradiation and analysis of neutron activation samples.

3.3.4 Data Reduction and Analysis

X-ray fluorescence data will be reduced using the program XRF-11 written by Criss Software, Largo, MD. This program calculates elemental concentrations by comparing measured x-ray intensities to a library of intensities for rock standards of known compositions. The rock standards used for calibration are similar in composition to the tuffs being analyzed. The program uses fundamental parameters to make matrix corrections for x-ray absorption and fluorescence effects.

Electron microprobe data will be collected and processed using the Sandia TASK8 (Chambers, 1985). This system incorporates the empirical Bence and Albee (1968) method for correcting mineral compositions for differential matrix effects. ZAF (atomic number, adsorption, and fluorescence) data reduction (Duncumb and Shields, 1966) is also available for the microprobe.

Data from the neutron activation analysis will be processed using the program RAYGUN, a variant of the program GAMANAL (Gunnick and Niday, 1972) This program determines a background, gamma-ray peak areas, and gamma-ray energy for each input spectrum. It then assigns gamma rays by energy to radionuclides in a gamma-ray library, apportioning all gamma-ray intensities to specific radionuclides. Intensities are converted to elemental concentrations using irradiation, detector, and decay constants. Corrections for room background and fission product activity are also performed by RAYGUN.

All computer software will be developed, documented, used and controlled in accordance with the LANL YMP procedure for configuration management (TWS-QAS-QP-3.11) and the procedures for software control (TWS-QAS-QP-3.12 and QP-3.13).

3.3.5 Representativeness of Tests and Limitations and Uncertainties

This activity will provide representative chemical compositions of tuffs and their constituent authigenic minerals in both matrix and fractures for major lithologic and stratigraphic units at Yucca Mountain. Samples will be collected from drill holes, from outcrops, and from the exploratory shaft. These samples should provide an extensive data base with which to examine vertical and lateral chemical variability at Yucca Mountain. The limitations on this data set include the number and distribution of drill holes available for study. The effects of these limitations will be addressed by statistical studies as described in section 3.5 of this report. Manpower resources places another limitation on the number of samples that can be examined. In general, a 6,000-ft continuously cored drill hole requires 1 man-year for us to collect, analyze, and report data for whole rock samples and 1.5-2 man-years for fracture-lining minerals.

3.4 Role of Fractures and Faults as Past Transport Pathways and Evidence for Paleo-Water Table(s)

The role of fractures and faults as past transport pathways will be examined by analyzing the minerals that occur in fractures and faults and determining their sequence of deposition. Several episodes of deposition of fracture-lining minerals have occurred at Yucca Mountain, and the abundance and distribution of these minerals vary both with depth and with lateral position across the mountain. Fracture-lining minerals will be identified using binocular microscopy, XRD analysis, and scanning electron microscopy. Open fractures will be examined by binocular microscope and SEM to determine the depositional relationships of fracture-lining minerals. Thin sections will be examined with a petrographic microscope and also with the SEM if greater magnification is required. Minerals in fractures will be compared to the minerals present in the rock matrix to determine if the species of fracture-lining minerals deposited are controlled by wall-rock mineralogy. Chemical data will be obtained on the minerals to provide information on the nature of source fluids and conditions of deposition. Evidence for paleo-water table(s) may be found in the mineral morphology and/or composition and in the relationship of fracture-lining minerals to rock matrix and changes in that relationship with depth. The interpretive aspects of this subtask directly support the Study "History of Mineralogic and Geochemical Alteration at Yucca Mountain" (SCP Section 8.3.1.3.2.2.1) and the Calcite-Silica Study (SCP Section 8.3.2.5.2.1) by providing information about the deposition of minerals in fractures and faults at Yucca Mountain. Isotopic data obtained on fracture-lining minerals by the Calcite-Silica Study (8.3.1.5.2.1) and fluid inclusion data obtained in the Alteration History Study (8.3.1.3.2.2.1) will be integrated with the results of this activity to interpret mineral paragenesis.

3.4.1 Test Methods

Samples will first be examined under the binocular microscope and a fragment of the fracture surface will be prepared for SEM studies if appropriate. Most of the remainder of the fracture surface will be scraped with a tungsten carbide scraper to obtain a sample for XRD analysis. X-ray diffraction analyses will be performed as described in Section 3.2. Because of problems in obtaining representative samples, XRD of fracture-lining minerals is used primarly to identify the minerals present rather than quantifying their amount. A discussion of the problems encountered in quantifying the amounts of minerals present on fracture surfaces is given in Carlos (1987). Additional XRD analyses may be performed on clay separates. When the amounts of material are small, as is often the case for fracture coatings, the sample is suspended in water in a container and the clay fraction is siphoned off and stored for later XRD analysis. This results in an impure clay separate, but XRD of a glycolated clay sample still permits identification of clay minerals. Heulandite and clinoptilolite are two structurally related zeolites that occur as common fracture-

lining minerals in the unsaturated zone. To distinguish between heulandite and clinoptilolite, the sample is heated and reanalyzed by XRD as described by Mumpton (1960).

Examination by binocular microscope shows the extent of surface coverage by each mineral. The morphology and relationships of the coatings can be observed by using the SEM. Fragments representative of the fracture coating are broken off the core and mounted on aluminum stubs. The samples are then gold coated and examined with the ISI DS-130 SEM. Energy dispersive spectra are taken to identify the elements present. The data obtained are not quantitative because of the low atomic weight of the major elements, the gold coat on the sample, and the topography of the sample surface. The size of the grains, which may be only a few microns, can be determined. Open fracture samples intended for microprobe analysis may be carbon coated and examined in the SEM, but the image is not as sharp as with a gold coat. Thin sections may also be examined using the SEM. These are carbon coated, and quantitative analysis is possible using standards, but this method has not been employed because the electron microprobe (wavelength dispersive) is preferable. The high magnification (up to 10,000X on the lower stage) permits identification of thin layers in multiple-layered coatings.

The chemistry of the minerals will be determined by electron microprobe analysis of thin sections (Section 3.3) where possible, and of epoxy mounts or by direct analysis of fracture surfaces if necessary. For fibrous minerals, we will adapt the method described by Smith and Norem (1986) for microprobe analysis of palygorskite in a colloidal carbon paste. Neutron activation analysis (Section 3.3) may be used on mineral separates if more detailed trace chemistry would provide additional information on depositional conditions and if sufficient material is available for analysis.

Cathodoluminescence may also be used to examine different generations of fracture-lining minerals. The usefulness of cathodoluminescence will depend on the types and amounts of trace elements in the fracture-lining minerals. Procedures will be developed for this analytical method as it applies to fracture minerals if it appears that the method is feasible and will provide needed information on mineral paragenesis.

The following procedures will be used in the examination of chemistry and paragenesis of fracture minerals to determine the role of fractures and faults as past transport pathways:

1. Thin Section Preparation Procedure, TWS-ESS-DP-04.
2. Operating Instructions for DV-502 Vacuum Evaporator Used in Carbon Coating Samples, TWS-ESS-DP-06.
3. Microprobe Operating Procedure, TWS-ESS-DP-07.
4. Siemens X-Ray Diffraction Procedure, TWS-ESS-DP-16.
5. Clay Mineral Separation and Preparation for X-Ray Diffraction Analysis, TWS-ESS-DP-25.
6. Nevada Test Site Fracture-Filling Studies Procedure, TWS-ESS-DP-28.
7. Sputter Coater Operating Procedure for Gold Coating Samples, TWS-ESS- DP-50.
8. Operating Instructions for International Scientific Instruments Model DS-130 Scanning Electron Microscope and Tracor Northern Series II X-Ray Analyzer, TWS-ESS-DP-112.

9. Procedure for Neutron Activation Analysis, TWS-ESS-DP 117.

3.4.2 Required Accuracy and Precision

The methods used in this activity are the same and have the same precisions and accuracies as those described in sections 3.1.2 and 3.3.2 of this Study Plan. This activity requires accurate identification of minerals present in fractures, but high precision on individual amounts is not necessary because of the problems of sample representativeness described above. For the purposes of this Study, the precision and accuracy of electron microprobe analyses are considered adequate for mineral identification when used in conjunction with XRD analysis. The precision and accuracy are also adequate for determining the chemical variability of fracture-lining minerals laterally and with depth. Textural relationships are determined by visual inspection of cross-cutting relationships and of superimposition of mineral phases; these observations will be made using both a microscope and an SEM. Using the combination of methods employed in this study, the experienced geologist familiar with these instruments will be readily able to identify minerals and textural relationships. Examination of many samples yields patterns of fracture filling and eliminates the possibility of a single atypical sample leading to erroneous conclusions.

3.4.3 Equipment Required

All of the equipment required for this activity is presently available at Los Alamos. The thin section laboratory is capable of making any kind of mount required for microprobe or SEM analysis. Analytical equipment, such as microscopes, Siemens D-500 x-ray diffractometers, Cameca automated electron microprobe, and an ISI model DS130 SEM, is available for use. Facilities exist for irradiation and analysis of neutron activation samples and for cathodoluminescence examination of rock fragments and thin sections.

3.4.4 Data Reduction and Analysis

X-ray diffraction data will be reduced as described in Section 3.1.4; electron microprobe data will be collected and processed as described in Section 3.3.4. SEM data are qualitative and consist of peak identification performed by the Tracor Northern IDENT program on energy dispersive data.

3.4.5 Representativeness of Tests and Limitations and Uncertainties

Because of the nonuniform distributions and amounts of fracture-lining minerals at Yucca Mountain, the results obtained for this activity can be representative of the repository block only if a large suite of samples is examined. For this reason samples will be collected from all available cored holes and from the exploratory shaft and drifts. Identification and chemical analysis of some minerals may not be possible because of the limited amount of material available in the fractures. Exploratory shaft and drift samples will have more fracture surface area available for sampling so the role of fractures and faults in past transport will be best characterized for these samples. The prototype test for sample collection (WBS 1.2.6.9.4.1.3) will address sample-collection procedures for fracture studies in the exploratory shaft and drifts. Interpretations of evidence for paleo-water table(s), for the role of fractures as transport pathways at depth, and for the lateral variation in past transport through fractures will be based on data for samples collected within drifts of the exploratory shaft and on data for samples collected from surface based exploratory drill holes. The collection and interpretation of data will be limited by the number and distribution of drill cores and by the time and budget constraints on the number of samples we are able to analyze.

3.5 Statistical Evaluation of Mineralogic, Petrographic, and Chemical Data

Statistical analyses of mineralogic and modal petrographic data will consist of probabilistic modeling and statistical extrapolation of mineralogic, modal, and chemical data from the drill holes in Section 2.4.1 of this Study Plan. Probabilistic analysis of mineralogic data will be used to (1) detect lateral and vertical trends in mineralogy; (2) correlate mineralogic and modal petrographic data with the internal stratigraphy of the repository host rock; and (3) detect outliers, possible measurement or reporting errors, and other anomalies in the data. Geostatistical extrapolation will be used to extrapolate mineralogic and petrologic contacts between drill holes where probabilistic modeling indicates the presence of lateral trends.

Based on the work above and on a review of other basic statistical considerations, recommendations will be made for optimizing drill-hole densities and distributions. Recommendations will also be made to optimize the design of sampling activities within drill holes and in the exploratory shaft to ensure that the field and laboratory data collected are representative of the site and that the variance in probabilistic models is minimized.

The optimization of drill-hole densities and within-hole sampling is properly a function not only of the variability of mineralogic, petrographic, and chemical parameters within the site, as discussed in Section 2.4.3, but also of 1) the sensitivity of results of activities described in SCP 8.3.1.3.7.1 and elsewhere to uncertainties in these parameters, and 2) economic cost analysis for drilling, sampling, and analysis programs. The development of this information is outside the scope of this Study Plan, but to the extent that it is available it will be used to modify recommendations based on statistical models of intrinsic variability in the data. As discussed in SCP section 8.4.2.2, drill holes will be chosen so as to provide a statistically valid set of samples for various site investigations including activities in this Study. Purely statistical recommendations will be based on data from existing drill core, data from prototype sampling, and data from the new drill holes (Section 2.4.1 of this Study Plan) as they become available. Reports will be periodically issued to evaluate the adequacy of the proposed drilling plan (SCP Section 8.4.2.2) for characterization of the mineralogy, chemistry and petrography of rocks at Yucca Mountain (see milestone list in Section 5).

3.5.1 Methods

The methods used in the probabilistic modeling will consist of standard statistical analyses, including: (1) the use of histograms, bivariate scatter plots, and other exploratory data-analysis tools to evaluate data; (2) analysis of variance and multiple regression to determine between-hole variability and to estimate significant lateral and vertical trends; and (3) canonical correlation and analysis of variance to investigate the relationship between mineralogy and stratigraphy. Log-ratio models (Aitchison, 1986) will be employed.

Statistical extrapolation will employ kriging to extend the mineralogic and petrologic data from a limited number of drill holes into a three-dimensional mineralogic model of Yucca Mountain. Use of kriging assumes that the data can be usefully modeled as observations from a nonstationary stochastic process, which is an intrinsic random function (Matheron, 1973; Journel, 1986). The method is extensively documented in the literature (e.g., Clark, 1979). The sensitivity of results to selection of a kriging model will be investigated. Sample reuse techniques, such as cross-validation and bootstrapping, will be used to exploit the data as fully as possible and to verify error estimates.

Commercial statistics computer programs, such as SAS (1982), will be used to make basic statistical calculations wherever possible. A technical document describing the use of these commercial computer programs with log-ratio models will be prepared.

Kriging techniques are being implemented at Los Alamos by in-house programming. Cross-validation and bootstrap (Campbell, 1987) methods are also being programmed in-house.

All data analyses in this section are Quality Level I activities; therefore, both the in- house and the commercial computer codes used in this study will be subject to outside peer review for validation.

3.5.2 Data Input Requirements

The input data required for probabilistic modeling and geostatistical extrapolation consist of mineralogic, modal, and chemical data for samples collected from drill holes and outcrops. Drill-hole locations and sample depths are also required as input parameters. Statistical requirements for additional drill hole data can be determined only after sensitivity analysis requirements (SCP Section 8.3.1.3.7.1) for the potential repository are known.

3.5.3 Expected Data Output and Accuracy of the Analysis

The output from the statistical analyses described above are probabilistic models of mineral and chemical distributions and variability. In addition, anomalous data can be identified for further study or reanalysis. Significant trends in the mineral and chemical data may indicate the need for a formal extrapolation procedure for the construction of a three-dimensional mineralogic model.

Kriging will provide an estimate of the expected value of a parameter at a point conditional on the observations and the conditional estimation error. These results depend on the choice of a model for the generalized covariance function of the process, which must usually be estimated from the same data. We will evaluate various functional forms. The most important factor affecting accuracy is the variability inherent in the input data and the density of available observations.

3.5.4 Representativeness of Approach

The representativeness of the models produced ultimately depends on the representativeness of the available data. Some of the drill holes to be studied have been located to sample anomalous surface or subsurface features (e.g., USW G-5 and USW G-6). The remaining drill holes selected for this study provide areal coverage of the exploration block and of the surrounding area. These latter drill holes are representative by definition. Data from feature-sampling holes will be compared to data from the representative holes to assess the representativeness of the former. The representativeness of individual samples will be assessed by statistical outlier detection techniques (Beckman and Cook, 1983).

The geostatistical extrapolation technique described above provides some guidance for the desirable distribution and density of drill holes to achieve the desired level of accuracy in extrapolation. A report will be issued that will contain recommendations about lateral and vertical sample densities to minimize the variance of probabilistic models and to ensure representativeness of the resulting models.

4. APPLICATION OF RESULTS

The information derived from the activities described in this Study Plan will be used in the following issues, investigations, and information needs:

Issue, Investigation, or Information Need	Subject
SCP 8.3.1.2.3.1	Mineralogic data from this Study will be used in the design and interpretation of infiltration and tracer flow tests done for geohydrology.
SCP 8.3.1.3.2.2	Mineral-chemical and mineralogic studies will aid investigations of thermal stability, expansion/contraction behavior, and hydration/dehydration behavior in zeolites, clays, and glasses proximal to the disturbed zone.
SCP 8.3.1.3.2.2.1	The mineralogic, chemical, and petrographic data from this Study will provide information about the alteration history of tuffs at Yucca Mountain.
SCP 8.3.1.3.3	Mineralogic and chemical data from this study will identify the mineral species and glass compositions of interest for studies of mineral and glass stability.
SCP 8.3.1.3.4	The mineralogic and chemical data gathered in this Study Plan will identify the mineral species and rock compositions appropriate for use in investigations of radionuclide retardation by sorption. The mineralogic and chemical data also provide a basis for assigning sorption retardation factors to potential groundwater flow paths at Yucca Mountain.
SCP 8.3.1.3.7.1 and 8.3.1.3.7.2	Secondary minerals are highly sorptive of many important radionuclides, and the distribution and abundance of these minerals in fractures and bulk rocks at Yucca Mountain will strongly influence radionuclide retardation by sorption processes along flow paths to the accessible environment. The mineralogic data will constrain both the quantitative models of Section 8.3.1.3.7 and performance assessment calculations for Issue 1.1. In order to consider all potential flow paths to the accessible environment, the mineralogic and chemical data must be extrapolated between widely spaced drill holes. The statistical studies in this study plan will identify the uncertainties resulting from these extrapolations.
SCP 8.3.1.4.1	The study of the internal stratigraphy of the Topopah Spring Member will aid repository construction by ensuring that working elevations can be determined should faults of uncertain amount and sense of displacement be crossed during mining operations.
SCP 8.3.1.4.2.1	The whole-rock chemical data can contribute to stratigraphic studies of the volcanic units at the site.
SCP 8.3.1.5.2.1.5	The fracture mineralogy activity will provide information about the composition and paragenesis of fracture-lining minerals at Yucca Mountain that will be used in interpretation of near-surface calcite-silica deposits.

Issue, Investigation, or Information Need	Subject
SCP 8.3.1.9.2.1.1	The whole-rock chemical data collected in this Study can be used to supplement other data collected for the geochemical assessment of Yucca Mountain in relation to the potential for mineralization.
SCP 8.3.1.15	Mineralogic data will be used in the design and interpretation of tests done on the physical properties of rocks.
SCP 8.3.1.15.1.8	Mineralogic studies of fractures and bulk rocks will provide information on the abundance and distribution of fibrous zeolites (erionite and mordenite) that may be hazardous to the health of workers during construction of the repository.
SCP 8.3.4.2	Mineralogic and chemical data from this study will be used in design and interpretation of investigations of chemical stability of the waste package and repository components.
SCP 8.4.2.2	The statistical information produced in this Study will be used to evaluate the adequacy of the proposed integrated drilling program to characterize the mineralogy, chemistry, and petrogrpahy of Yucca Mountain for performance and design issues.
Issues 1.6.3 and SCP 8.3.1.3.2	All tests in this study plan are important components in the accurate description of paths from the disturbed zone to the accessible environment. Statistical studies of the mineralogic and chemical data will identify the uncertainties in our description of these paths.

5. SCHEDULE

The schedule and milestones are presented below. Only major milestones are noted on the schedule chart represented in Figure 3.

Milestones

R603 Issue progress report on image analysis for Topopah petrographic database.

R597 Complete compilation of petrographic and mineralogic data for peer reviewers and comparison with available outcrop.

R623 Issue report on manganese minerals in USW G-4 fractures.

M335 Issue report on summary of three dimensional mineralogic variation along transport pathways.

M337 Issue report on the precision, accuracy, and alternative interpretation for models of mineralogy along transport pathways.

New* Optimization of core and shaft sampling based on prototype sampling.

M334 Issue report on petrographic stratigraphy within the Topopah Spring Member with evaluation of lateral variability within the candidate repository horizon.

R757 Issue report on the comparison of fracture mineralogy between drill cores at Yucca Mountain.

R701 Update report on the mineralogic evaluation of transport pathways at Yucca Mountain.

New Preliminary evaluation of adequacy of proposed drilling plan for characterization of mineralogy, chemistry, and petrography of Yucca Mountain.

R548 Issue summary report on quantative x-ray diffraction data for mineralogy along transport pathways at Yucca Mountain.

M339 Issue report on statistical evaluation of Topopah Spring exploratory shaft samples, contrasted with core samples relevant to the exploration block at Yucca Mountain.

New Update report evaluating adequacy of proposed drilling plan for characterization of mineralogy, chemistry, and petrography of Yucca Mountain.

R702 Issue update report on mineralogic evaluations of transport pathways at Yucca Mountain.

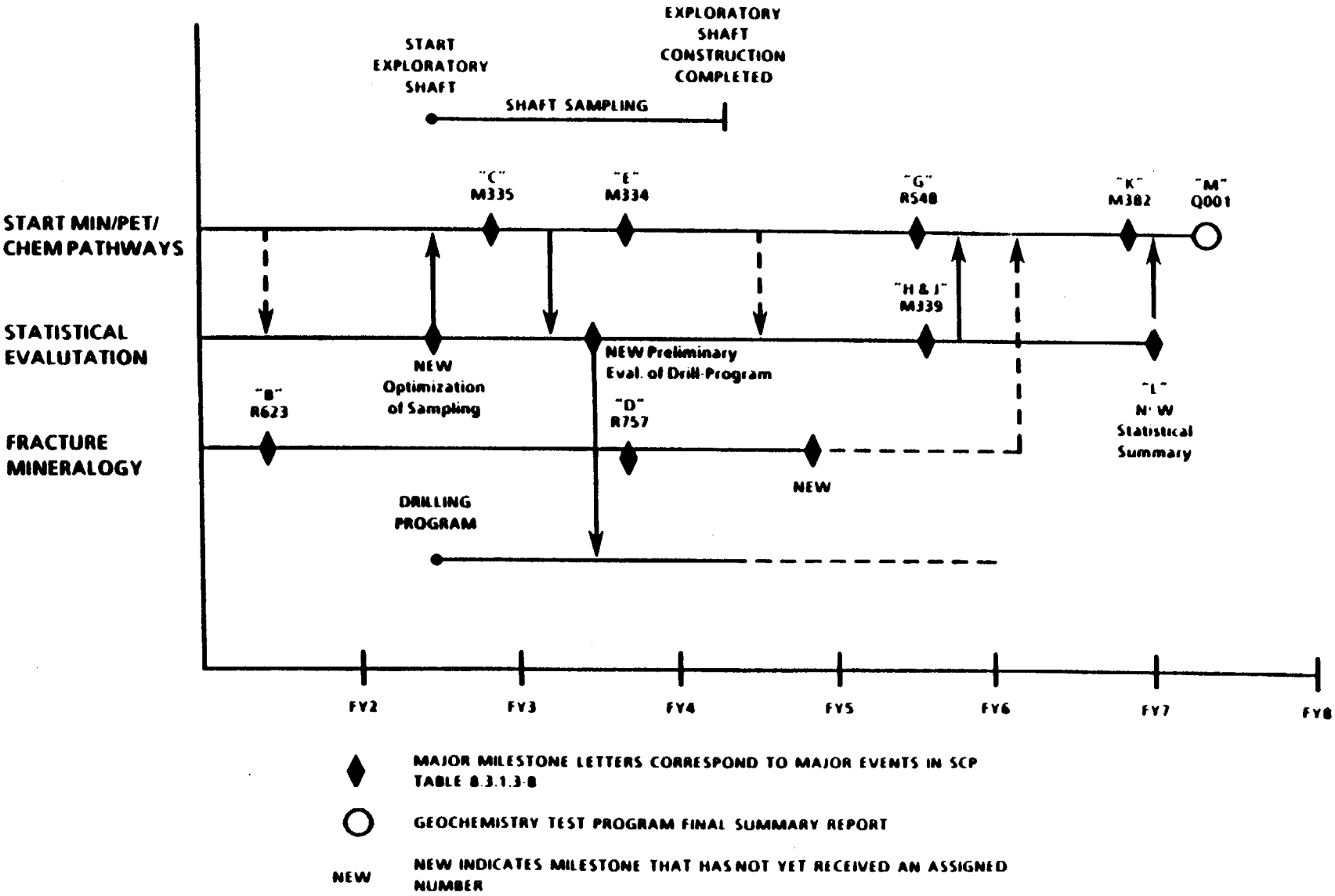


Figure 3. Milestones for Studies on Mineralogy, Petrology, and Chemistry of Transport Pathways

M382 Complete mineralogic evaluation of transport pathways at Yucca Mountain.

New Statistical summary for extrapolating mineralogic, chemical, and petrographic data between drill holes.

Q001 Issue report on the summary of results defining the geochemical characterization (mineralogy/petrology, mineral stability, and water chemistry) at Yucca Mountain.

* New indicates milestone which had not been assigned a milestone number at the time this Study Plan was prepared.

Additional information on schedules and milestones can be found in SCP Sections 8.5.1.5 and 8.5.6. All activities in this study plan and the study plan for alteration history (SCP Section 8.3.2.3.2.2.1) can be conducted in parallel.

Most of the activities in this study plan are based upon subsurface samples. Therefore, schedules and milestones are constrained by sample availability, which is tied to the drilling schedule, construction of the exploratory shaft, and the operation of the core library. A drilling schedule is being prepared at this time (SCP Section 8.4.2.2). If a significant number of new holes are drilled, and additional numeralogic and petrologic characterization is found to be necessary, the work outlined in this study plan would sharply increase. The timing of construction of the exploratory shaft will also have a major impact on schedules and milestones. SCP Section 8.3.1.3.2.4 describes how milestones will be affected by delays in the start of the exploratory shaft. In particular, milestones addressing mineralogic evaluation of transport pathways (R548, R701, R702, and M382) will be significantly affected by delays in the exploratory shaft and in the drilling schedule. The milestone in which statistical evaluations of lateral variability in mineralogy will be made for the candidate host rock (M334) is based upon data provided by the milestones addressing mineralogic evaluation of transport pathways. Delays in the earlier milestones will affect the completion dates for the statistical studies. The summary of results of the geochemical characterization at Yucca Mountain (milestone M382) will be based in large part on data produced under this Study Plan. Delays in the exploratory shaft and in the drilling program could seriously delay the milestones leading to the completion of M382.

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APPENDIX A

QUALITY ASSURANCE SUPPORT DOCUMENTATION

Table A-1 lists the applicable NQA-1 criteria for this study and explains how they will be satisfied.

TABLE A-1

APPLICABLE NQA-1 CRITERIA FOR SCP STUDY 8.3.1.3.2.1
AND HOW THEY WILL BE SATISFIED

NQA-1 Criterion	Documents Addressing These Requirements		Anticipated Date of Issue
1. Organization	The organization of the Office of Civilian Radioactive Waste Management (OCRWM) program is described in Section 8.6 of the SCP. The LANL QA program is described in the LANL-YMP-QAPP and includes a program description addressing each of the NQA-1 criteria. The LANL QA program contains quality administrative procedures (QP) further defining the program requirements.		
	TWS-QAS-QP-01.1	Interface Control	1/31/89
	TWS-QAS-QP-01.2	Stop Work Control	1/31/89
	TWS-QAS-QP-01.3	Conflict Resolution	2/21/89
2. QA Program	The LANL QA program is described in the LANL-YMP-QAPP and includes a program description addressing each of the NQA-1 criteria. An overall description of the YMP QA program for site characterization activities is described in Section 8.6 of the SCP.		
	TWS-QAS-QP-02.1	Personnel Selection, Indoctrination, and Qualification	1/31/89
	TWS-QAS-QP-02.2	Personnel Training	1/31/89
	TWS-QAS-QP-02.3	Readiness Review	5/31/89
	TWS-QAS-QP-02.4	Management Assessment	5/31/89
	YMP AP-5.4Q	Assignment of Quality Assurance Level	1/24/89
3. Design and Scientific Investigation Control	This study is a scientific investigation. The following QPs apply:		
	TWS-QAS-QP-03.1	Software QA Plan	4/30/89
	TWS-QAS-QP-03.2	Technical and Policy Review	4/30/89
	TWS-QAS-QP-03.3	Preparation of SCP Study Plan	5/31/89
	TWS-QAS-QP-03.5	Documenting Scientific Investigation	2/29/89
	TWS-QAS-QP-03.6	IDS Design and Interface Control	5/31/89
	TWS-QAS-QP-03.7	Peer Review	5/31/89

TABLE A-1

APPLICABLE NQA-1 CRITERIA FOR SCP STUDY 8.3.1.3.2.1
AND HOW THEY WILL BE SATISFIED
(continued)

NQA-1 Criterion	Documents Addressing These Requirements		Anticipated Date of Issue
	TWS-QAS-QP-03.8	IDS Technical Assessment Review	5/31/89
	TWS-QAS-QP-03.11	Software Configuration Management	6/16/89
	TWS-QAS-QP-03.12	Scientific and Engineering Software and Software Libraries	6/16/89
	TWS-QAS-QP-03.13	Auxiliary, Commercial, and Utility Software	6/16/89
	TWS-QAS-QP-03.14	Design Input for ESF	2/3/89
	TWS-QAS-QP-03.15	TMO Design and Interface Control	5/31/89
4. Procurement Document Control	TWS-QAS-QP-04.1	Procurement	12/14/88
	TWS-QAS-QP-04.2	Acceptance of Procured Services	1/31/89
	TWS-QAS-QP-04.3	Qualification of Suppliers	1/31/89
5. Instructions, Procedures, and Drawings	TWS-QAS-QP-05.1	Preparation of QPs	12/14/88
	TWS-QAS-QP-05.2	Preparation of DPs	12/14/88
6. Document Control	TWS-QAS-QP-06.1	Document Control	1/31/89
7. Control of Purchased Material, Equipment, and Services	Applicable parts of this criterion are covered in item 4 (see above).		
8. Identification and Control of Materials, Parts and Samples	TWS-QAS-QP-08.1	Identification and Control of Samples	5/31/89
	TWS-QAS-QP-08.2	Control of Data	5/31/89
9. Control of Special Processes	This criterion has been determined to be inapplicable to the scope of work of the LANL YMP.		
10. Inspection	This criterion has been determined to be inapplicable to the scope of work of the LANL YMP.		
11. Test Control	This criterion has been determined to be inapplicable to the scope of work of the LANL YMP.		

TABLE A-1

APPLICABLE NQA-1 CRITERIA FOR SCP STUDY 8.3.1.3.2.1
AND HOW THEY WILL BE SATISFIED
(concluded)

NQA-1 Criterion	Documents Addressing These Requirements		Anticipated Date of Issue
12. Control of Measuring and Test Equipment	The control of instrument calibration and data collection is described in the technical procedures referenced in Section 3 of this plan. The following QPs also apply:		
	TWS-QAS-QP-12.1	Measuring and Test Equipment	5/31/89
	TWS-QAS-QP-12.2	Control of Operator-Calibrated Equipment	5/31/89
13. Handling, Storage and Shipping	TWS-QAS-QP-13.1	Handling, Shipping, and Storage	3/17/89
14. Inspection, Test and Operating Status	This criterion has been determined to be inapplicable to the scope of work of the LANL YMP.		
15. Nonconforming Materials, Parts or Components	TWS-QAS-QP-15.1	Nonconformances	12/14/88
16. Corrective Action	TWS-QAS-QP-16.1	Corrective Action	4/28/89
	TWS-QAS-QP-16.2	Trending	5/31/89
17. Quality Assurance Records	TWS-QAS-QP-17.1	Resident File	12/14/88
	TWS-QAS-QP-17.2	Records Processing Center	12/14/88
18. Audits	TWS-QAS-QP-18.1	Audits	4/28/89
	TWS-QAS-QP-18.2	Surveys	3/17/89
	TWS-QAS-QP-18.3	Auditor Qualification	3/31/89

QUALITY ASSURANCE LEVEL ASSIGNMENT SHEET (QALAS)

AND

QUALITY LEVEL ASSIGNMENT CRITERIA SHEET (QLACS)

SIP No. 86/4.2

Rev. 0

Activity Mineralogy/Petrology

Tasks: Fracture Mineralogy

Alteration History

Mineralogy of Transport Pathways

The Quality Assurance Level Assignments (QALAs) included in this appendix were approved in 1986. Revised QALAs are currently being developed using new procedures that implement NUREG-1318. When these QALAs are approved, they will supersede the 1986 QALAs and will be provided through controlled distribution as a revision to the Study Plan.

QUALITY ASSURANCE LEVEL ASSIGNMENT SHEET (QALAS)

NNWSI QUALITY ASSURANCE LEVEL ASSIGNMENT			
Items/Activities	**QA Level**	**QA Requirements**	**Technical Justification**
Alteration and Fracture Mineralogy	I	1,2,3,4,5,6,7,8, 10,11,12,13,15, 16,17,18 See attached QLACS	NNWSI SOP-02-02: para.5.2.1bA (activity will provide site characterization data), and Step 2 of QA Level Assignment Checklist Only those items and sub-activities that directly control the quality of quantitative data will be considered Level I.

APPROVALS (Signature and Date)

PI R.T. Green 6-26-86 TPO [signature] 6-26-86

QAL [signature] 6-26-86 WMPO(TECH) [signature] 7-14-86

QAIM [signature] 6/24/86 WMPO(POM) [signature] 7/14/86

PI FINAL REVIEW [signature] 10/9/86

QUALITY LEVEL ASSIGNMENT CRITERIA SHEET (QLACS)

SIP No. 86/4.2

Rev. 0

Activity: Mineralogy/Petrology

Task: Fracture Mineralogy

PI: D. T. Vaniman D.T.V. [illegible]

QA Criterion	Applies	Does not Apply	Comments
1. QA Organization	x		
2. QA Program	x		
3. Design and Scientific Investigation Control	x		Only scientific investigation requirements apply
4. Procurement Document Control	x		
5. Instructions, Procedures, and Drawings	x		
6. Document Control	x		
7. Control of Purchased Material, Equipment, and Services	x		
8. ID and Control of Materials, Parts, Components, and Samples	x		
9. Control of Processes		x	Activities performed under this WBS are not considered to be special processes as per definition in Appendix A SOP-02-01
10. Inspection	x		Applicable for surveillance requirements only
11. Test and Experiment/Research Control	x		
12. Control of Measuring and Test Equipment	x		

QA Criterion	Applies	Does not Apply	Comments
13. Handling, Shipping, and Storage	x		
14. Inspection, Test, and Operating Status		x	No hardware generated in this task
15. Control of Nonconformances	x		
16. Corrective Action	x		
17. QA Records	x		
18. QA Audits	x		

QUALITY ASSURANCE LEVEL ASSIGNMENT SHEET (QALAS)

NNWSI QUALITY ASSURANCE LEVEL ASSIGNMENT

Items/Activities	QA Level	QA Requirements	Technical Justification
Mineralogy of Transport Pathways	I	1,2,3,4,5,6,7,8, 10,11,12,13,15, 16,17,19	NNWSI SOP-02-02: para.5.2.1bA (activity will provide site characterization data), and
		See attached OLACS	Step 2 of QA Level Assignment Checklist Only those items and sub-
			activities that directly control the quality of quantitative data will be
			considered Level I.

APPROVALS (Signature and Date)

PI 6-26-86 TPO 6-26-86

QAL 6-26-86 NNWPO (TECH) 7-14-86

QAIR 6/26/86 NNWPO (PQM) 7/14/86

PI FINAL REVIEW 10/9/86

QUALITY LEVEL ASSIGNMENT CRITERIA SHEET (QLACS)

SIP No. 86/4.2

Rev. 0

Activity: Mineralogy/Petrology

Task: Mineralogy of Transport Pathways

PI: D. T. Vaniman D.T.V Lum 7/7/90

QA Criterion		Applies	Does not Apply	Comments
1.	QA Organization	x		
2.	QA Program	x		
3.	Design and Scientific Investigation Control	x		Only scientific investigation requirements apply
4.	Procurement Document Control	x		
5.	Instructions, Procedures, and Drawings	x		
6.	Document Control	x		
7.	Control of Purchased Material, Equipment, and Services	x		
8.	ID and Control of Materials, Parts, Components, and Samples	x		
9.	Control of Processes		x	Activities performed under this WBS are not considered to be special processes as per definition in Appendix A SOP-02-01
10.	Inspection	x		Applicable for surveillance requirements only
11.	Test and Experiment/ Research Control	x		
12.	Control of Measuring and Test Equipment	x		

QA Criterion	Applies	Does not Apply	Comments
13. Handling, Shipping, and Storage	x		
14. Inspection, Test, and Operating Status		x	No hardware generated in this task
15. Control of Nonconformances	x		
16. Corrective Action	x		
17. QA Records	x		
18. QA Audits	x		

The following number is for Office of Civilian Radioactive Waste Management Records Management purposes only and should not be used when ordering this document:

Accession Number: NNA.890602.0001

Study Plan for
Study 8.3.1.2.2.2

Water Movement Tests

Revision 0

January 1989

U.S. Department of Energy
Office of Civilian Radioactive Waste Management
Washington, DC 20585

Prepared by
Los Alamos National Laboratory

UNCONTROLLED

Study Plan for
Study 8.3.1.2.2.2

Water Movement Tests

Revision 0

January 1989

U.S. Department of Energy
Office of Civilian Radioactive Waste Management
Washington, DC 20585

Prepared by
Los Alamos National Laboratory

Study Plan Number 8.3.1.2.2.2

Study Plan Title Water Movement Tests

Revision Number R0, January 1989

Prepared by:
Los Alamos National Laboratory

Date:
January 1989

Maxwell B. Blanchard 1-9-89
Director, Regulatory and Site Evaluation Division Date

J Valdez for J Blaylock 1-9-89
Project Quality Manager Date

11-9-89
Project Manager Date

WATER MOVEMENT TEST

Los Alamos National Laboratory

ABSTRACT

The water movement tracer test is designed to produce information derived from isotopic measurements of soil and tuff samples collected from Yucca Mountain that is pertinent for assessing the performance of a nuclear waste repository. Measurements of chlorine isotopic distributions will help characterize the percolation of precipitation into the unsaturated zone. The chlorine-36 in the unsaturated zone occurs from atmospheric fallout of chlorine-36 produced by cosmic-ray secondaries reacting with argon-40, and, to a lesser extent, with argon-36 and as global fallout from high-yield nuclear weapons tests conducted at the Pacific Proving Grounds between 1952 and 1963. When chloride ions at the surface are washed underground by precipitation, the radioactive decay of the chlorine-36 in the chloride can be used to time the rate of water movement. The chlorine-36 half-life of 301,000 yr permits the detection of water movement in the range of approximately 50,000 to 2 million years. These data are part of the input for developing numerical models of groundwater flow at this site.

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STUDY PLAN FOR WATER MOVEMENT TEST
Site Characterization Plan Study 8.3.1.2.2.2

1.0 PURPOSE AND OBJECTIVES OF STUDY

1.1 Purpose

This study consists of a single activity (8.3.1.2.2.2.1). The purpose of this study is to determine the rate of water movement downward through the unsaturated zone beneath Yucca Mountain, using measurements of chloride concentrations and chlorine isotopic compositions in samples of soil and tuff collected as part of the site characterization program. The objective of one phase of this study is to determine an upper bound on the amount of water that enters Yucca Mountain by infiltration. The objective of the second phase is to time water movements in the unsaturated zone by measuring chlorine-36/total chlorine ratios in samples that will be collected as the exploratory shaft is mined. The 301,000-yr half-life of chlorine-36 is useful for tracing water movements between 50,000 and 2,000,000 yr and is most useful between 100,000 and 1,000,000 yr.

The data from this test will be used as part of the information required by the Yucca Mountain Project (YMP) to calculate releases to the accessible environment. These data will help establish an accurate model of the hydrologic characteristics of the unsaturated zone at Yucca Mountain. The hydrologic model will be used to compute radioactivity releases to the accessible environment as part of the repository performance assessment.

Another use of the data will be to estimate the rate of technetium-99 movement through the unsaturated zone. The technetium-99 is likely to be in the chemical form TcO_4^-, which, like chloride, is a nonsorbing geochemical form. The rate of movement of technetium will be no faster then the chlorine-36 rate of movement.

1.2 Resolution of Performance Issues

The rationale for the YMP site characterization program is presented in Section 8.1 of the YMP Site Characterization Plant (SCP) (DOE, 1988). The issues-based strategy was guided first by an issue identification procedure and then by performance allocation to define the activities needed to resolve the issues. The issues were divided into performance issues and design issues. The work in this study plan applies only to performance issues.

The primary issues that will use the data from this study are the following:

Issue 1.6: Will the site meet the performance objective for pre-waste-emplacement ground-water travel time as required by 10 CFR 60.113?

Issue 1.1: Will the mined geologic disposal system meet the system performance objective for limiting radionuclide material to the accessible environment as required by 10 CFR 60.112 and 40 CFR 191.13?

The measurements described in this study plan do not directly contribute to any of the performance parameters (discussed in SCP Sections 8.3.5.12 and 8.3.5.13) that will be used to calculate ground-water travel time and total system performance. Those parameters are generally hydrologic properties of the rocks and fluids that will be used to construct models of flow and transport at Yucca Mountain. Instead, as noted in SCP

Section 8.3.5.12 (Issue 1.6), the isotopic measurements described here will provide important information that may confirm or invalidate model predictions of ground-water velocities and fluxes in the unsaturated zone. Section 2.2 of this study plan discusses the interpretation of the isotopic data with respect to the determination of rates of water movement.

1.3 Regulatory Rationale and Justification

As indicated in the discussion of performance issues, this study could provide support concerning compliance with several key regulations. The Department of Energy's siting guidelines [10 CFR 960.4-1-2(b)(1)] specify that a pre-waste-emplacement ground-water travel time greater than 10,000 yr along any path of likely radionuclide travel from the disturbed zone to the accessible environment would be a favorable condition. The long travel times that this test can measure will bear directly on the evaluation of this favorable condition. The data may be used to determine the nature and rates of hydrologic processes that have occurred during the Quaternary Period, which are specified in 10 CFR 960.4-2-1(b)(2). The sampling procedure for this test (see Section 3.1 below) is designed to detect stratigraphically influenced changes in the rate of water movement through the unsaturated zone. Such changes, if detected, will be used for validating the modeling of the geohydrologic system that is required in 10 CFR 960.4-2-1(b)(3). All of the above information will be used to support the higher level findings on the geohydrology disqualifying and qualifying conditions specified in 10 CFR 960.4-2-1(a) and (d).

The second major source of regulatory requirements is the technical criteria of the US Nuclear Regulatory Commission (NRC). In 10 CFR 60.113(a)(2), the NRC requires that the pre-waste-emplacement ground-water travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment shall be at least 1,000 yr. The NRC also specifies that the geologic repository system performance following permanent closure shall conform to the applicable environmental standards for radioactivity as established by the Environmental Protection Agency (10 CFR 60.112). The hydrologic flux in the unsaturated zone is an important component of the total system performance assessment, and the measurements in this study are part of the site characterization process to determine the unsaturated-zone flux.

2.0 RATIONALE FOR USE OF CHLORINE-36 AND CHLORIDE TO TRACE WATER MOVEMENT IN THE UNSATURATED ZONE AT YUCCA MOUNTAIN

2.1 Estimates of Rates of Water Movement from Hydrologic Data

Determining the rate of water movement through the unsaturated zone at Yucca Mountain is one of the most important tasks for assessing the future performance of a nuclear waste repository, but it is a very difficult task. Montazer and Wilson (1984) discuss the data on water movement available through 1984. Their hydrologic terminology is used in this study plan, as it is in the YMP SCP (DOE, 1988). Estimates of downward flux through the potential repository host rock, the moderately to densely welded portion of the Topopah Spring Member of the Paintbrush Tuff formation, range from 1×10^{-7} to 0.2 mm/yr. These estimates were based on hydraulic gradient and effective permeability data derived from one borehole and from cores recovered from holes at more than one location. Analyses of geothermal heat-flux data from the same tuff unit indicate that the net hydrologic flux may be upward at a rate of 1 to 2 mm/yr, possibly from vapor-phase transport. Montazer and Wilson (1984) state that the hydrologic flux through the tuffaceous beds of Calico Hills, which underlie the host rock, is likely to be variable, but less than about 0.006 mm/yr downward, as estimated from

measurements of effective hydraulic conductivities from core samples that included the zeolitic facies of this unit.

The hydrologic flux estimates outlined in the preceding discussion do not give a definitive picture of the rate of water movement to be expected through the unsaturated zone. If the flux through the Topopah Spring Member is assumed to be about 0.2 mm/yr downward, then estimates of ground-water travel time through the unsaturated zone are greater than 100,000 yr. Such estimates indicate that chlorine-36 techniques would provide data useful for hydrologic modeling.

2.2 Radiometric Determination of Rates of Water Movement

Direct measurements of the rate of water movement through the unsaturated zone would be of great value. Radiometric methods are one potential technique for making such measurements. Determinations of tritium and carbon-14 in the unsaturated zone are discussed in the hydrochemistry study plan (8.3.1.2.2.7). The 5,730-yr half-life of carbon-14 permits dating to ages of 60,000 yr under favorable conditions. Other radiometric dating techniques have been considered. A survey of such techniques given by Phillips (1984) indicates that radiometric dating with iodine-129 may be possible for waters older than 10^6 years. The applicability of this technique to waters moving through the unsaturated zone at Yucca Mountain may be limited by the lack of a useful iodine-129 source. The technique chosen to determine the water travel time through the unsaturated zone in this study is the measurement of chlorine-36 as a function of depth. Chlorine is deposited globally both in precipitation and in dry fallout. The source of most of the chlorine in this fallout is sea salt lofted into the troposphere by surface winds. A very small fraction of chlorine atoms in the fallout consists of chlorine-36, which results from cosmic ray reactions with argon in the atmosphere. The chlorine-36 half-life of 301,000 yr is appropriate for the travel times calculated from the hydrologic data. Geochemical properties of chlorine make it a useful tracer of subterranean water movements (Bentley et al., 1986). Chlorine is so electronegative that it exists as the nonvolatile chloride ion under most geohydrologic conditions. Bentley et al. (1986) state that chloride ions are among the least sorbed ions on solid surfaces because of their negative charge and small radius. Measurements of chlorine-36 discussed in Bentley et al. (1986) indicate the validity of using this technique for tracing water movements over long times.

At Yucca Mountain the technique discussed in this study plan will measure chloride carried into the tuff by meteoric water and now present in pore water or on the surfaces of the tuffs. This chloride traces the movement of water in the liquid phase through the unsaturated zone. Chlorine originally present in the tuffs (the chlorine-36 component of which should have decayed to negligible amounts at the present) may be included in the samples. Most of this chlorine may be chemically bound. Short leaching times should help minimize the introduction of this chlorine into the samples for the chlorine-36 measurements.

Measurements to aid in interpreting the chlorine-36 data include chloride concentration with depth and stable chlorine isotope ratios. The chloride concentration profile is expected to be relatively uniform, if the water movement in the unsaturated zone is uniform. Deviations in the chloride concentration profile may result from nonuniform evaporation or from mingling of waters caused by localized cross-cutting features. These data may help confirm patterns of nonuniform flow in the chlorine-36 data. The stable chlorine isotope ratio measurements may indicate that detectable differences can be observed in the chlorine-35/chlorine-37 ratio, depending on the origin of the chlorine. Such differences have been reported recently (Desauiniers et al. 1986). At Yucca

Mountain, the chlorine-35/chlorine-37 studies may show that chlorine of meteoric origin has one ratio whereas chlorine originally present in the tuff has a different ratio. The chlorine-36 content associated with chlorine of meteoric origin is the only quantity of interest. Measurements of chlorine-35/chlorine-37 ratios in the samples for chlorine-36 analysis can be compared with the ratio determined for chlorine of meteoric origin and with the ratio measured for chlorine from tuff to correct the chlorine-36/chlorine ratio to that which should be observed in chlorine of meteoric origin.

The specific activity of chlorine-36 in the environment is so low that measurements of the chlorine-36 isotopic abundance have not been feasible, with a few exceptions, until the recent development of tandem accelerator mass spectrometric analyses. The sensitivity of this technique currently is approximately one atom of chlorine-36 in 10^{15} atoms of chlorine. The sample size required for these measurements is 10 mg of chloride or more. The background chlorine-36/chlorine ratio in surficial deposits of alluvium at Yucca Mountain has been measured in this work to be approximately 5×10^{-13}, which is more than 100 times greater than the limit of this technique. Any samples collected in which chlorine-36 has undergone detectable radioactive decay will result in chlorine-36/chlorine ratios lower than that of the cosmogenic background. Radiometric determinations are limited to samples that have been isolated from isotopic exchange with cosmogenic sources of chlorine-36.

Several recent studies suggest that chlorine-36 may be a suitable indicator of the rate of water movement. Andrews et al. (1986) used the chlorine-36/chlorine ratio to estimate ground-water residence times at the Stripa mine in Sweden and formulated conceptual ground-water flow paths to explain the evolution of the ratio.

Norris et al. (1987) used measurements of chlorine-36 in soil samples from two locations near Yucca Mountain to determine the infiltration of precipitation during the past quarter century and to examine the differences in surficial hydrologic infiltration between the two sites. The source of the chlorine-36 measured in this work was not from cosmic ray reactions with argon in the atmosphere. Instead, the chlorine-36 was deposited globally as fallout from high-yield nuclear weapons tests that were conducted at the surface of the Pacific Ocean between 1952 and 1962. The data can be interpreted in terms of an infiltration rate at Yucca Wash, located to the east of Yucca Mountain, of 1.8 mm/yr during the past quarter century. This value represents an in situ measurement of flux that is valuable in establishing the upper bound for the amount of water flowing downward through the unsaturated zone.

The mechanisms of water transport in the unsaturated zone are of interest for appropriate modeling of radionuclide transport. However, the chlorine-36/chlorine data from this study are unlikely to discriminate between fracture flow and porous flow because the chloride that is measured can result from water flow by a combination of mechanisms. The chlorine-36/chlorine data may shed light on the mechanism of water flow only if rapid fracture flow dominates to the extent that bomb pulse chlorine-36 is observed at great depths or if the hydrologic flow is so slow that hydrologists would describe the mechanism as porous flow.

2.3 Constraints on Chlorine-36 Studies

Analytical and Sampling Constraints

The specific activity of chlorine-36 present in tuff samples from Yucca Mountain, as in typical samples from other environments, is too small to permit direct measurements of the radioactive decay of chlorine-36. Conventional mass spectrometry can be used to

measure chlorine-36/chlorine ratios as low as 10^{-10}, but the ratios in Yucca Mountain are approximately 5×10^{-13} for samples with contemporary cosmogenic chlorine-36. Therefore, the only feasible technique for this study is tandem accelerator mass spectrometry. The 10 mg of chloride required for the chlorine-36/chlorine measurement will be leached from crushed tuff samples, as described in Section 3 of this study plan. The chloride content of tuff samples from the Paintbrush Tuff formation at Yucca Mountain necessitates collecting about 40 kg of rock per sample. The collection process should involve little or no contact of water with the sample to be collected, to avoid inadvertent removal of the chloride before the leaching process that is part of the analysis procedure.

These constraints led to the necessity for using tuff samples collected as the exploratory shaft is mined. Some water will be used in the drilling and blasting operations, but large rubble pieces can be chosen to minimize any wetting of the major part of the rubble volume. This study could not be performed with core samples from conventional surface-based drilling, in which water is used as the lubricant for the drilling bit.

Samples will be collected from the exploratory shaft as shown in Figure 1. The sampling locations indicated were selected on the basis of stratigraphic data from USW G-4. The strata might be factors in controlling the downward movement of water through the unsaturated zone penetrated by the exploratory shaft. The chlorine-36 half-life constrains the interpretation of the data to water movements that have taken longer than 30,000 yr, because too little chlorine-36 decay has occurred to be detectable for younger times. Measurements of samples collected from the upper part of the exploratory shaft may give no useful data because of this threshold limitation. The half-life of chlorine-36 also constrains the measurements of age differences between samples to those that are greater than 30,000 yr. The data from deeper samples should provide information about water movement in the tuff above the repository horizon as well as below it.

The impact of this study on the potential repository site will be negligible. Each sample will require that about 40 kg of rubble be used for analysis. Preliminary plans call for the water used to construct the exploratory shaft to be tagged with 20 ppm of bromide. This will permit detection and correction for approximately 10 ppm of chlorine in that water. Some samples for chloride profile studies may be at shallow depths (<10 m) in locations of potential infiltration, but these locations will be selected after a field study of Yucca Mountain.

The analytical techniques for this study are available and are described in Section 3 of this plan. Cosmogenic chlorine-36 in samples of Yucca Mountain alluvium has been measured (Norris et al. 1987). The tandem accelerator mass spectrometric measurements have to be performed when the apparatus is available. There are a sufficient number of tandem accelerator users that a wait of several months can be expected. Exploratory shaft operations are not affected by this wait. The time required for interpretation of the chlorine isotope data does not constrain any other activity.

Chlorine-36 can be produced underground from neutron capture by chlorine-35. The neutrons result from the presence of uranium and thorium and their decay chains. Some neutrons come from spontaneous fission of the first members of the decay chains. The remainder are produced by (α,n) reactions on light elements. Calculations will be performed to determine whether <u>in situ</u> production of chlorine-36 will constrain the interpretation of the data from this test.

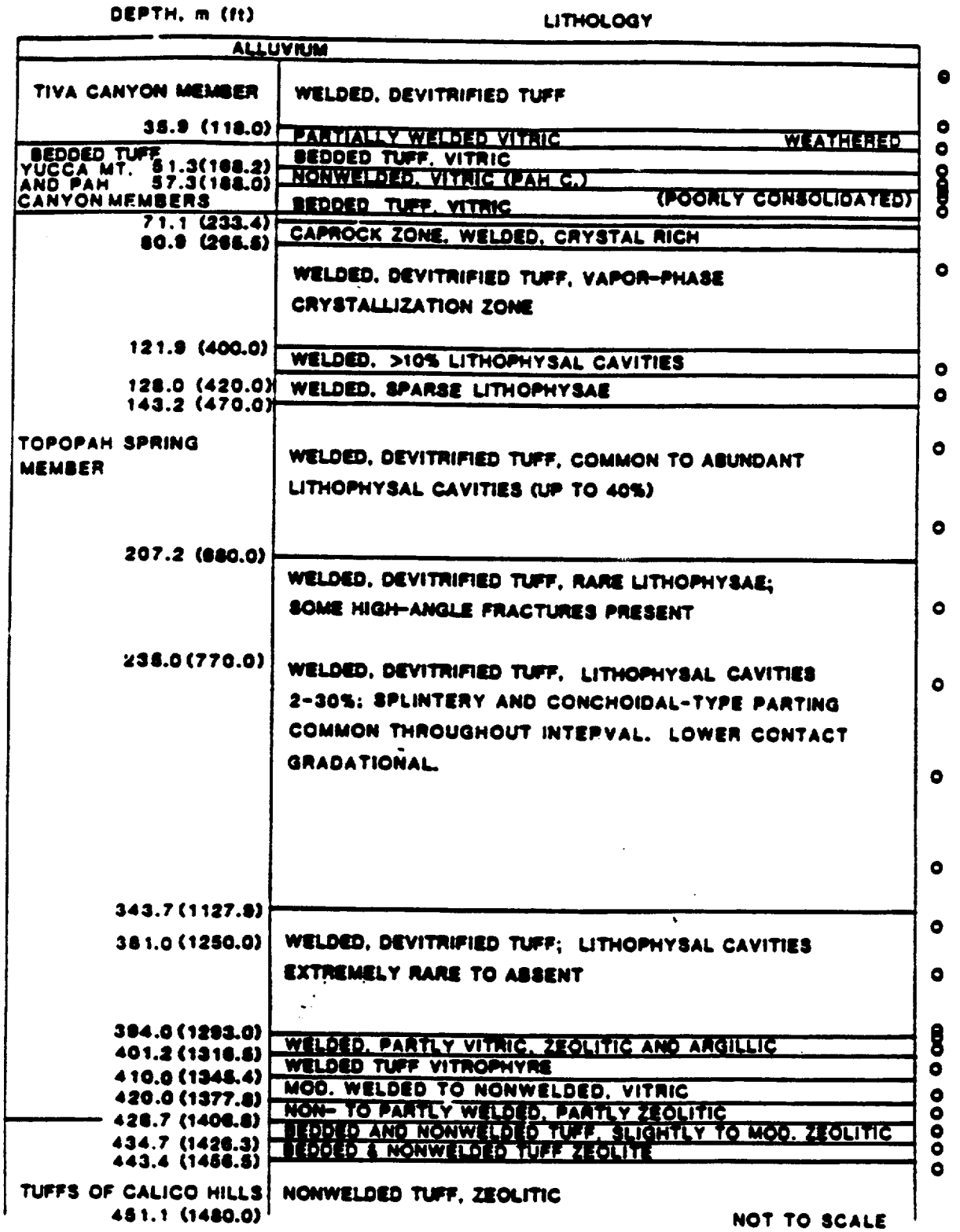

Figure 1. USW G-4 stratigraphic column with proposed chlorine-36 sampling locations shown as circles. Total sampling depth will be constrained by the depth of the Exploratory Shaft Facility.

2.4 Potential for Interference with the Chlorine-36 Studies

The interferences to which this study is susceptible from exploratory shaft operations are due to the use of water, which has been discussed above, and the introduction of chlorine that could alter the in situ chlorine-36/chlorine ratio. The explosives used in mining the exploratory shaft may contain chlorine with negligible chlorine-36. Samples for this study will be collected to minimize the possibility of contamination from chlorine in the explosives.

3.0 DESCRIPTION OF CHLORINE-36 STUDY

The key parameter to be measured in this study is the ratio of chlorine-36 to total chlorine as a function of depth in the exploratory shaft at Yucca Mountain. Location of the exploratory shaft is shown in Figure 2.

3.1 Sample Collection

Most of the sample collection will be performed as the exploratory shaft is mined. The principal borehole (USW G-4) stratigraphy was used to select sampling depths on the basis of lithology and stratification that might be significant for hydrologic characteristics. When there were no stratigraphic features to guide the selection of sampling intervals, the maximum interval between samples was set arbitrarily at 30 m (100 ft). The locations of samples are shown in Figure 1. The depths of sampling are subject to minor modifications to account for the dip of the beds between USW G-4 and exploratory shaft 1 (ES-1) and because the stratigraphy at ES-1 may not be exactly the same as that at USW G-4. The data from the Shaft-Wall Mapping Test (see geologic study plans) will be monitored to ensure that the blasting rounds will be sampled where significant lithologic changes occur.

Sampling will be performed in accordance with the procedures that will be developed by the YMP Sample Overview Committee.

After each designated round, a geologist will descend to the working face of ES-1 to select rubble pieces larger than 130 mm (6 in.) in diameter for transport to the surface before the customary washdown. At the surface, the rubble may be segregated into a special container. A 208-L (55-gal) barrel will be packed with 100 to 200 kg (220 to 440 lb) of rubble and labeled with the depth from which the rubble was collected.

Accidental contamination of samples with chlorine-36 is not expected to be a problem. Chlorine-36, unlike carbon-14, is not transported in the vapor phase. No special atmospheric protection is necessary during sample preparation. Quantities of chlorine-36 produced from nuclear reactors or particle accelerators are not stocked routinely where the chlorine-36 sample preparation is likely to be performed.

Most chlorine that might accidentally contaminate the samples from ES-1 would come from chloride ions in the Well J-13 water used in construction and from chlorine in the explosives that will be used during shaft-sinking operations. Therefore, the selection of larger pieces of rubble and the postponement of the customary washdown after blasting are two steps taken to mitigate potential sample contamination problems. The chloride content of Well J-13 water is approximately 10 mg/L. The water used underground will be tagged with a sodium bromide tracer. The bromide concentration of the Well J-13 water will be increased to 20 ppm, which is $\geq 10^3$ times the natural bromide concentration. The bromide content of the rubble selected for chlorine-36 analysis will

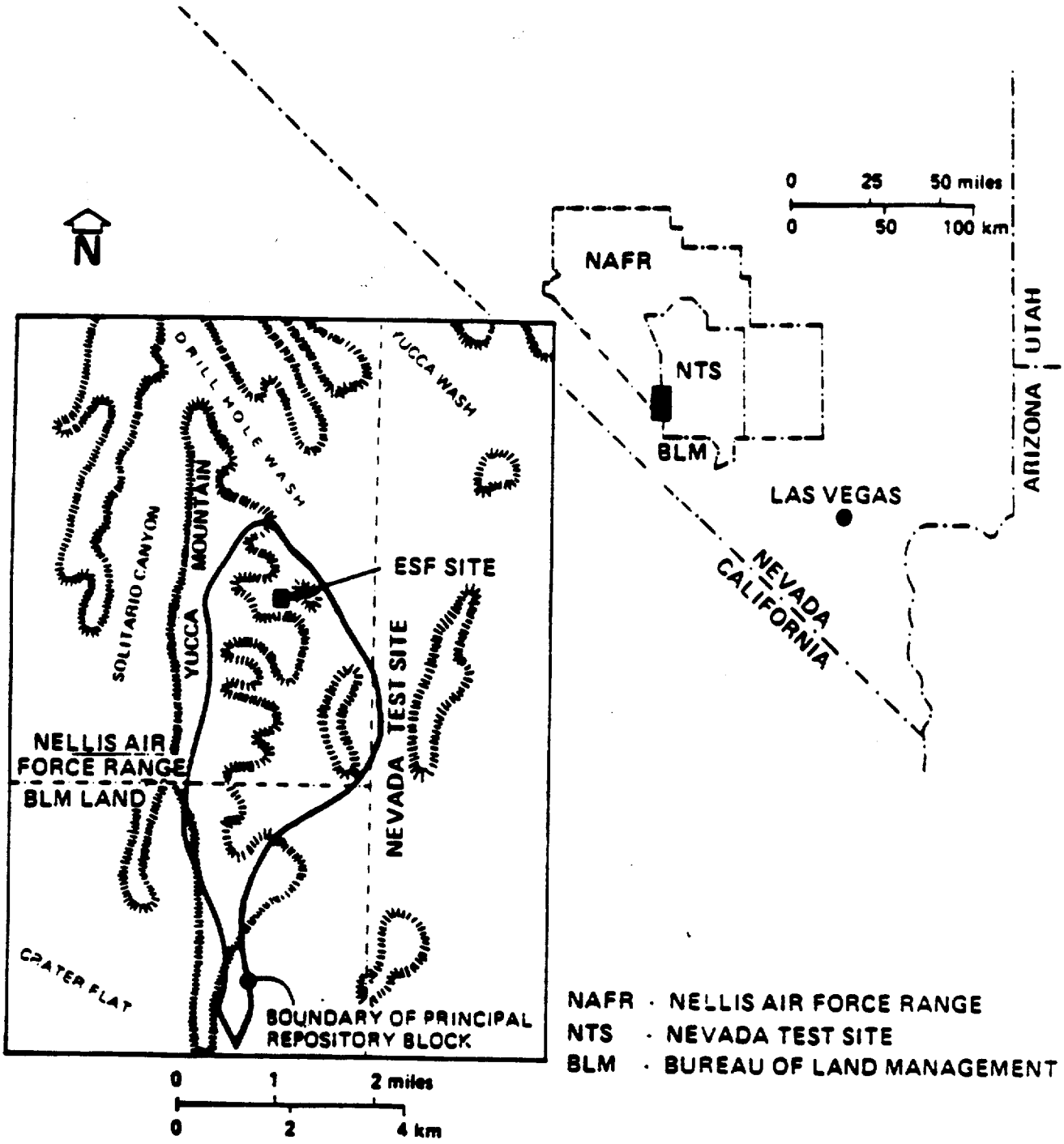

Figure 2. Relationship of the exploratory shaft facility to the Yucca Mountain site.

be measured to permit the calculation of the chloride that might have been introduced from Well J-13 water. Finally, a chlorine analysis of all the explosives used during the mining operations will be obtained and used to set a bound on the maximum amount of chlorine that could contaminate the samples from explosives.

The introduction of chlorine from Well J-13 water and from explosives is expected to result in at most a minor perturbation in the data because the quantities of chlorine are small. Explosives customarily contain chlorine as a minor or a trace constituent. A problem more difficult to evaluate is the downward movement of water used in construction, which may leach chloride from tuff below the working depth before samples are collected for this test. Selecting rubble pieces with large diameters may ameliorate this problem, because water flow into the interior of an intact piece of tuff is slow. If the data indicate that leaching before sample collection is a problem, additional samples can be obtained by using horizontal dry coring techniques. The shaft liner and the surrounding tuff can be penetrated to a depth where the downward flow of water used in construction is unlikely to be a problem.

Some samples for measuring the chloride profile at depths to a few meters below the surface may be collected independently of the exploratory shaft mining operations, particularly if the hole for the exploratory shaft collar is excavated in a way that precludes obtaining samples at known depths. These data will aid in interpreting the chlorine-36 data by providing a source term for the expected quantity of meteoric chloride.

Any water encountered in sufficient volume during the construction of the exploratory shaft will be sampled and analyzed for chlorine-36. Pore water samples will be analyzed for chlorine-36 if sufficient volume can be obtained (see SCP Section 8.3.1.2.2.8, Hydrochemistry).

The Yucca Mountain Project is considering drilling deep boreholes with dry drilling techniques. Samples from various depths in these boreholes will be requested for chlorine-36 analyses. If the data from the first few boreholes indicate no significant variation with depth or with location, the sampling will be discontinued.

3.2 Measurement of Chlorine-36/Chlorine Ratio

The chlorine-36/chlorine ratio will be measured in the tuff samples collected from ES-1. A subcontractor will be chosen to prepare the rock samples and perform the analyses of chlorine-36, because a highly specialized technique is used (Elmore et al. 1984a). The rubble selected for the chlorine-36/chlorine ratio measurements will be crushed. The bromide content will be measured to determine the quantity of chloride from well J-13 water in the sample, and the crushed rock will be contacted with chloride-free water. Silver nitrate will be added to the water to precipitate about 50 mg of silver chloride. This precipitate will then be analyzed for the chlorine-36/chlorine ratio in a tandem accelerator mass spectrometer.

Descriptions of the apparatus and the techniques currently being used for tandem accelerator mass spectrometric analyses of chlorine-36 are given in Elmore et al. (1984a). Chlorine in the form of silver chloride is accelerated first as negative ions to eliminate interferences from argon-36, which does not form negative ions. The chlorine ions pass through an argon gas stripper in the center of the tandem accelerator. Ions with a charge of +7 are selected for mass analysis in a 90 degree magnetic analyzer. Chlorine-35 and chlorine-37 are measured in a multiplate gas ionization detector. Measurement of energy loss in this detector permits separation of chlorine-36 ions from

interfering sulfur-36 ions. Measurements of chlorine-36 with precisions as good as ±5% have been obtained. The data in this study plan, from analyses performed on a routine basis, are expected to be measured with a one standard deviation (σ) precision of ±10%.

3.3 Analysis and Interpretation of Isotope Data

Table 1 summarizes the parameters that will be measured in this study and provides expected values. The range of expected values for the chlorine-36/chlorine ratio is determined at the upper end by the contemporary quantity of cosmogenic chlorine-36 and at the lower end by the sensitivity of the tandem accelerator mass spectrometric technique. The bromide will be added as a tracer to tag the water used in the exploratory shaft; the maximum quantity added will be 20 ppm. The ion chromatography sensitivity limit is 20 ppb. The limit on the sample collection depth is determined by the total depth of the exploratory shaft. The final part of this test is the analysis and interpretation of the data.

TABLE 1

PARAMETERS MEASURED IN THIS TEST

Procedure	Parameter Measured	Expected Value
Tandem accelerator mass spectrometry	Chlorine-36/chlorine	1 to 600 x 10^{-15}
Ion chromatography	Total bromide	≤20 ppm
Linear measurement	Depth of samples in ES	≤457 m (<1500 ft)
ASTM mercuric nitrate titration	Chloride concentration	1 to 1000 mg/kg rock
Conventional mass spectrometry	Chlorine-37/chlorine-35	-1 to 3 per mil relative to standard mean ocean chloride

The techniques used to obtain the chlorine-36/chlorine isotope ratios from tandem accelerator mass spectrometry measurements are documented in a paper by Elmore et al. (1984b). That paper discusses the calculation of the ratio of chlorine-36 to chlorine-35 + chlorine-37 in the sample, in a National Institute of Standards and Technology (NIST) chlorine-36 standard, and in a reagent blank. The isotope ratios are corrected for mass fractionation, for background, and for interferences arising from the presence of sulfur-36. The NIST chlorine-36/chlorine ratios are used to normalize the ratios in the samples for inaccuracies introduced by the tandem accelerator. The value of the final chlorine-36/chlorine ratio in the sample is calculated as the mean of the corrected and normalized ratios from a sequence of measurements, weighted by the uncertainty of each determination.

Interpretation of the chlorine-36 data in terms of the rate of water movement through the unsaturated zone will require the consideration of processes that differentiate chloride movement from water movement. One process is that of anion exclusion. Positively charged components in the subterranean mineralogic environment can exclude

negatively charged ions, which causes the anionic tracer to move slightly faster than tritiated water (Daniels 1983). The second aspect of chloride movement that is important for hydrologic modeling is the nonvolatile character of these anions. If water movement through the unsaturated zone should be in downward pulses through the matrix in the liquid phase, followed by upward movement in the vapor phase, the chloride ions would move only in the liquid phase. The chlorine-36 decay data, then, might show an age that results from mixing chloride ions from more than one pulse. The data in this case still would be useful for calculating the average travel time of a radioactive waste nuclide such as technetium-99, which is expected to be transported in water as the TcO_4^- ion. Like chloride, the pertechnetate ion is both nonvolatile and nonsorbing.

A premise of data interpretation for this study is that the chlorine-36 fallout has been constant throughout the Quaternary Period. Experimental evidence bearing on this premise is being sought in ice cores from Camp Century, Greenland (Elmore et al. 1984a). A perturbation in the constancy of the chlorine-36 fallout occurred between 1952 and 1962. High-yield nuclear weapons tests at sea level in the Pacific Ocean resulted in significantly increased global fallout of chlorine-36. This "bomb pulse" has been used to measure infiltration that occurred during the past 30 yr into the top few meters of sandy loam in New Mexico (Bentley et al. 1986) and into alluvium at Yucca Mountain (Norris et al. 1987). Hydrologic flow at Yucca Mountain may occur through fractures in tuff and by some lateral flow, particularly through the Tiva Canyon and Pah Canyon Members. If chlorine-36 values higher than background are encountered in samples from the exploratory shaft, the data will be examined to determine if fracture flow or lateral flow might account for the inclusion of "bomb pulse" chlorine-36.

The ratio of chlorine-36 to chlorine as a function of depth will be correlated with the measured chloride concentration profile and with detailed data on fracture orientation and frequency. Regions of nonuniformity in the chloride concentration profile indicate nonuniform flow rates, and such nonuniform flow rates might be observable in the chlorine-36/chlorine profile. The data concerning fracture characteristics and distributions, to be provided by the US Geological Survey (USGS), will be studied as one possible explanation for the nonuniform flow.

3.4 Accuracy and Precision of Water Velocity Determinations

The chlorine-36 concentration data, when plotted against sample depth, provide a measure of water velocity down through the unsaturated zone, if a vertical flow path is assumed. The accuracy of the measurement from this test depends on the rate of water movement down through the unsaturated tuff. For velocities less than 5 mm/yr, the accuracy is high. It decreases for higher water velocities until the practical limit of the test is reached at water velocities of about 10 mm/yr. For water velocities greater than 10 mm/yr, the shorter lived nuclides discussed in Section 2.2 will be used. The following statistical analysis shows the sensitivity of this technique.

Power curves were used to estimate the probability of detecting small water movement velocities from chlorine-36/chlorine ratio measurements at the depths indicated in Figure 1. The analysis is based on a constant water flow rate throughout the volume penetrated by ES-1. A null hypothesis was tested, namely that the rate of water flow through the unsaturated zone is greater than or equal to 15 mm/yr (which corresponds to a slope of -1.5×10^{-4} m^{-1} or greater when the natural logarithm of the chlorine-36/chlorine ratio is plotted versus depth). Figure 3 shows a plot of velocity versus power. Power is the probability of rejecting the null hypothesis, when the null hypothesis is false. The significance level of 0.05 implies a 5% chance of erroneously rejecting the null hypothesis. The three curves in the figure are labeled with the $\pm 1\sigma$ values of the individual data points.

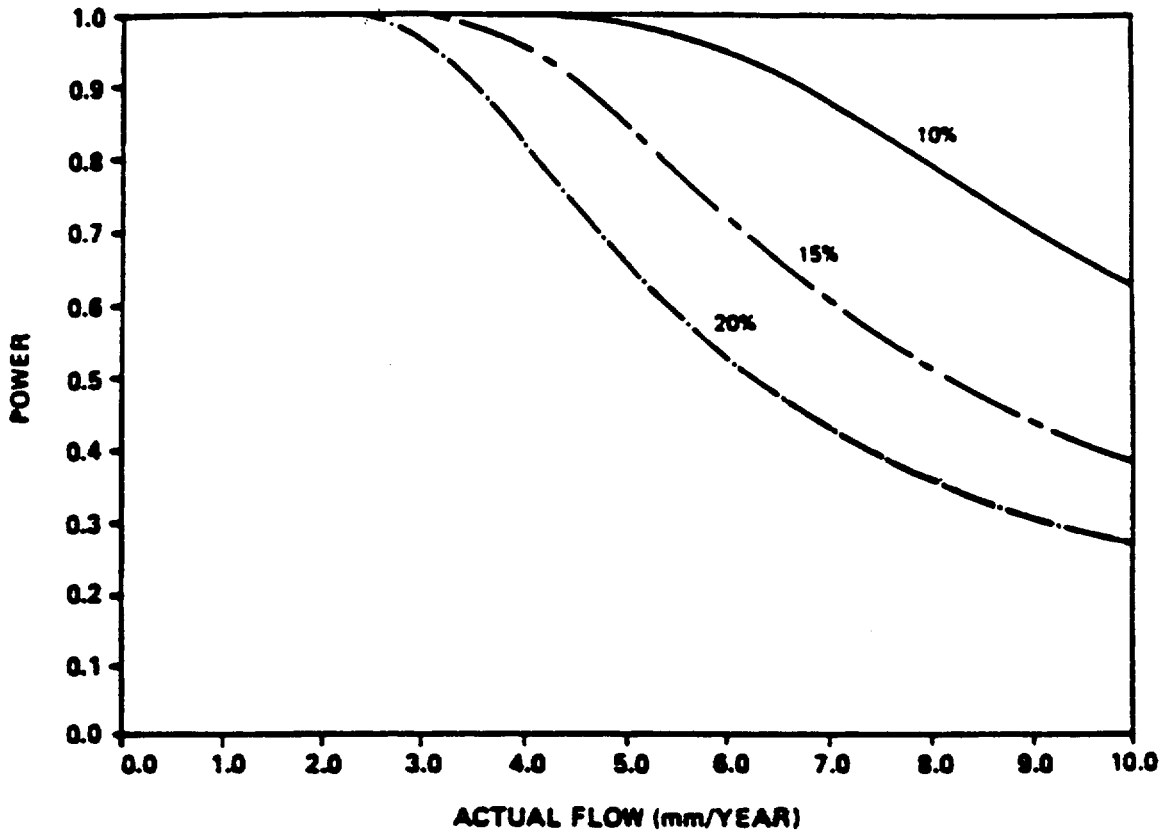

Figure 3. Power curves for measurements of the chlorine-36/total chlorine ratio. The curves are labeled with the ±1σ values (in percentages) of the individual data points.

The curves in Figure 3 show the probability that the measured data can distinguish between an actual velocity, shown on the abscissa, and the selected hypothetical velocity (greater than or equal to 15 mm/yr in this case). The curves show this probability for different uncertainties associated with the measured data. As the actual velocity approaches the hypothetical velocity, it becomes more likely that the two velocities cannot be distinguished. For example, when the actual velocity is 10 mm/yr, there is a 36% chance that the data will indicate a velocity greater than or equal to 15 mm/yr. However, when the actual velocity is less than about 5 mm/yr, there is essentially no chance that the data will indicate a velocity greater than 15 mm/yr.

Figure 4 shows a plot of the expected half-width of a symmetric 95% confidence interval for the average velocity. This plot shows that a velocity of 1 mm/yr can be estimated within a few percent. However, for a velocity of 5 mm/yr the error associated with the 95% confidence interval will be about ±2 mm/yr with $\pm 1\sigma = 10\%$ measurement errors, which are expected, and will be considerably larger as the measurement errors increase. The maximum flux is expected to be 0.2 mm/yr for a saturation of 0.65 and a porosity of 0.14 (Montazer and Wilson 1984), which is approximately equal to a water velocity of 2 mm/yr. Figure 4 shows that water velocities less than 2 mm/yr will be measured with small uncertainties.

3.5 Equipment and Services Required

Two special facilities are required at the ES-1 site. One is a box at the surface (see Table 2) into which the rubble collected at a particular depth can be poured. The purpose of this box is to separate the sample material from the spoils pile until the sample can be packed in 208-L (55-gal) barrels. The second facility required at the ES-1 site is a metering device (Table 2) to introduce a definite, small quantity of water tracer into all water that is used for mining ES-1. In practice, a bromide tracer will be added to all Well J-13 water used at the exploratory shaft site. A surge tank is likely to be the apparatus of choice for this application. Water samples will be analyzed periodically to verify the water tracer concentration. Water used at the surface for site preparation and dust control also will be tagged with a suitable tracer.

3.6 Representativeness of Velocity Determinations from the Exploratory Shaft

A question can be raised concerning the representativeness of the data from the exploratory shaft when it is extrapolated over the entire area of the repository, because the exploratory shaft allows access to only one point in the area. In the relatively unfaulted portion of Yucca Mountain, spatial results are expected to be fairly uniform. If downward water movement tends to be episodic with either short or long periodicity, interpretation of chlorine-36/chlorine ratios at different depths may be complicated. However, Montazer and Wilson (1984) indicate that such pulses are likely to occur only in the shallow unsaturated zone.

Representativeness of results is also influenced by the degree to which water transport occurs in the matrix of the tuff versus fractures. If most recharge occurs through major structural features as suggested in the conceptual model of Montazer and Wilson (1984), spatial variability may be large. Washes and other areas underlain by structural features would be likely to provide higher velocities, whereas relatively nonfaulted areas would provide lower velocities. The data of most concern to predictions of repository performance are those from the repository level and below. The potential variability in water velocities is therefore unlikely to cause significant changes in the determination of water movement by chlorine-36 tracer studies because the effects of temporal changes in infiltration are likely to be manifested only at shallow depths.

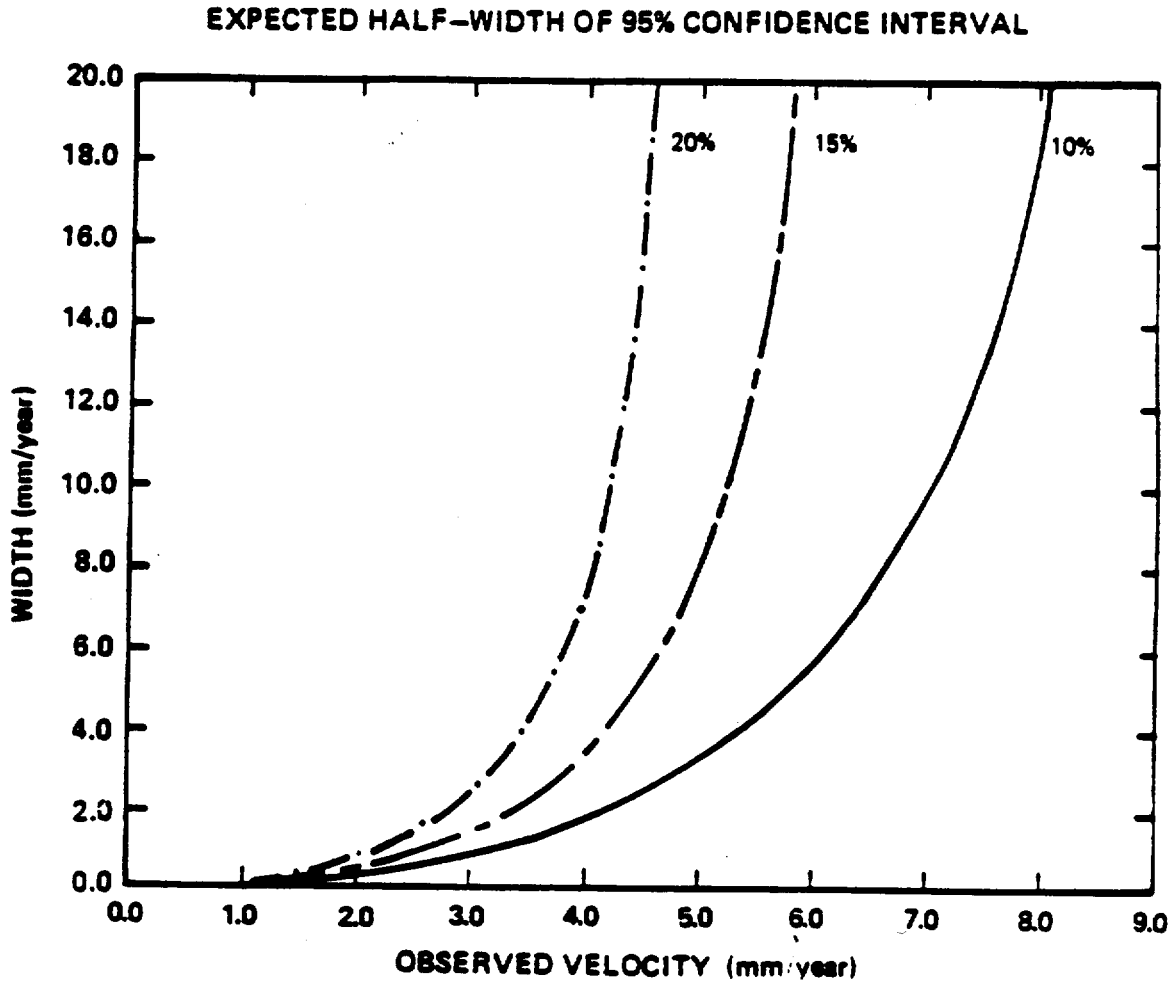

Figure 4. Confidence intervals for measurements of the chlorine-36/total chlorine ratio. The curves are labeled with the $\pm 1\sigma$ values (in percentages) of the individual data points.

TABLE 2

INSTRUMENTATION, EQUIPMENT, MATERIALS, AND SERVICES FOR THIS TEST

Item	Quantity	Description	Procurement Method
1. Box for rubble	1	Nonstandard	Designed and constructed by tester's organization
2. Water tracer metering system	1	Nonstandard	Designed and constructed by tester's organization
3. Water tracer, NaBr	1,120 kg	Standard	Tester's organization purchase order
4. 208-L (55-gal.) barrels	≤60	Standard	Tester's organization purchase order
SERVICES LIST			
1. Depth of designated blast-in ground		Standard	Shift-sinking subcontractor
2. Geologist to select and pack rubble pieces for chlorine-36 analysis (about 40 hours total)			Fenix and Scisson
3. Extract chloride from rubble; analyze for chlorine-36, chloride, and bromide; interpret data		Nonstandard	Tester's organization subcontractor

Samples could be collected at other locations by using a new dry-drilling technique, reverse vacuum drilling (Whitfield 1985). Correlation of the chlorine-36 results with detailed stratigraphic mapping of fracture frequency data would not be possible to the extent that will be possible in the exploratory shaft. If spatially distributed data are likely to improve knowledge of the hydrologic flow through the unsaturated zone, this alternative method of sample collection could be used at the later date.

Another source of material for chlorine-36 analyses is perched water that might be encountered during the construction of the exploratory shaft. If the chloride content of the perched water is 10 ppm, as in Well J-13 water, then 2 to 3 L per sample would be sufficient to obtain material for a chlorine-36 analysis. The data from these analyses might provide information about the rate of water flow in the unsaturated zone at Yucca Mountain.

3.7 Quality Assurance Requirements

The activities in this study plan have been assigned as Quality Level I in accordance with LANL QA procedure TWS-MSTQA-QP-18. (This procedure is currently being revised and

will be issued as TWS-QAS-QP-03.4.) These data may be used in the license application in assessing ground water travel times and ground water flow rates which have a direct bearing on site assessments concerning waste isolation to be used in the license application. The applicable criteria from NQA-1 that apply to this study are shown in Appendix A, along with the procedures and other documents that will satisfy these criteria.

Technical procedures for the work in this study are shown in Table 3.

TABLE 3

TECHNICAL PROCEDURES FOR STUDY PLAN 8.3.1.2.2.2

Activity	Technical Procedure	Type	Anticipated Availability Date
Sampling in Exploratory Shaft	YMP-AP-6.2Q, Borehole sample-handling activities	Nonstandard	TBD*
	YMP-AP-6.3Q, Sample management facility	Nonstandard	TBD*
	YMP-AP-6.6Q, Specimen removal	Nonstandard	TBD*
Field Sampling	To be prepared	Specialized standard	6/90
Sample Crushing and Leaching	To be prepared	Nonstandard	3/90
Chloride Concentration Measurement	ASTM Mercuric Nitrate Titration	Standard	1981
Bromide Concentration Measurement	To be prepared	Specialized standard	3/90
Chlorine Isotope Analyses	To be prepared	Specialized standard	6/90

* Procedures will be ready 30 to 60 days before tests.

4.0 APPLICATION OF RESULTS

4.1 Site Investigation

The work in this study plan will provide information for determining the ground water travel time in the unsaturated zone at Yucca Mountain. Water movements will be

characterized through measurements of the chloride concentrations and the chlorine-36/chlorine ratios, both as a function of depth below surface. Results from this study will be used in assessing water movement at the site. Information from chlorine-36 data may be used for inferring rates of fracture flow relative to matrix flow. The chlorine-36 vertical distribution may permit assessment of the role of convective water movement relative to dispersive movement. This study will be performed in parallel with USGS hydrochemistry studies (8.3.1.2.2.7) and will precede USGS in situ tests (8.3.1.2.2.4). The groups working on these tests plan to exchange information as they progress. The data will be used to validate conceptual models of hydrologic flow in the unsaturated zone by showing, from the chlorine-36 data, whether flow in the unsaturated zone has taken at least 50,000 years. Plans for integrated modeling of the unsaturated zone are described in Sections 8.3.1.2.2.8 and 8.3.1.2.2.9 of the SCP and will be detailed in later study plans. The use of rates of chlorine-36 migration as an upper bound on technetium-99 migration may also provide valuable confirmatory support to results from geochemical studies summarized in Sections 8.3.1.3 and 8.3.5.13 of the SCP.

4.2 Resolution of Performance Issues

The application of results in the site investigation work can be tied directly to resolution of key performance assessment issues. The assessment of total system performance summarized in Section 8.3.5.13 of the SCP is dependent upon the ranges of potential flux passing through and below the repository level. An independent confirmation of flux estimates by rates of movement derived from chlorine-36 studies would provide valuable support to the transport and release predictions. Both containment by the waste package (SCP Section 8.3.5.9) and release from the engineered barrier system (SCP Section 8.3.5.10) are strongly dependent upon the rate of water movement through the repository horizon. Therefore, confirmation of low flux values by independent analytical studies will reduce uncertainties in meeting the waste package and engineered barrier system performance objectives.

As indicated in Section 2 of this study plan, confidence in meeting the 1,000-yr pre-waste-emplacement travel time requirement will increase if chlorine-36 samples below the repository horizon indicate rates of movement far too slow for a shorter travel time.

5.0 SCHEDULE AND MILESTONES

Item	Date
Develop water metering system for NaBr tracer	Constructed and operational by time of exploratory shaft site preparation
Commence sample collection	Start of exploratory shaft construction
Conclude sample collection	Completion of exploratory shaft to depth
Complete chlorine-36/chlorine ratio analyses	1 yr after completion of exploratory shaft to depth
Complete data interpretation and final report	21 months after exploratory shaft completed to depth

A chart showing the anticipated progress in this study is shown in Figure 5.

	Milestone
R495	Infiltration rates from chlorine distributions at Yucca Mountain
M623	Final ESF chlorine-36 report

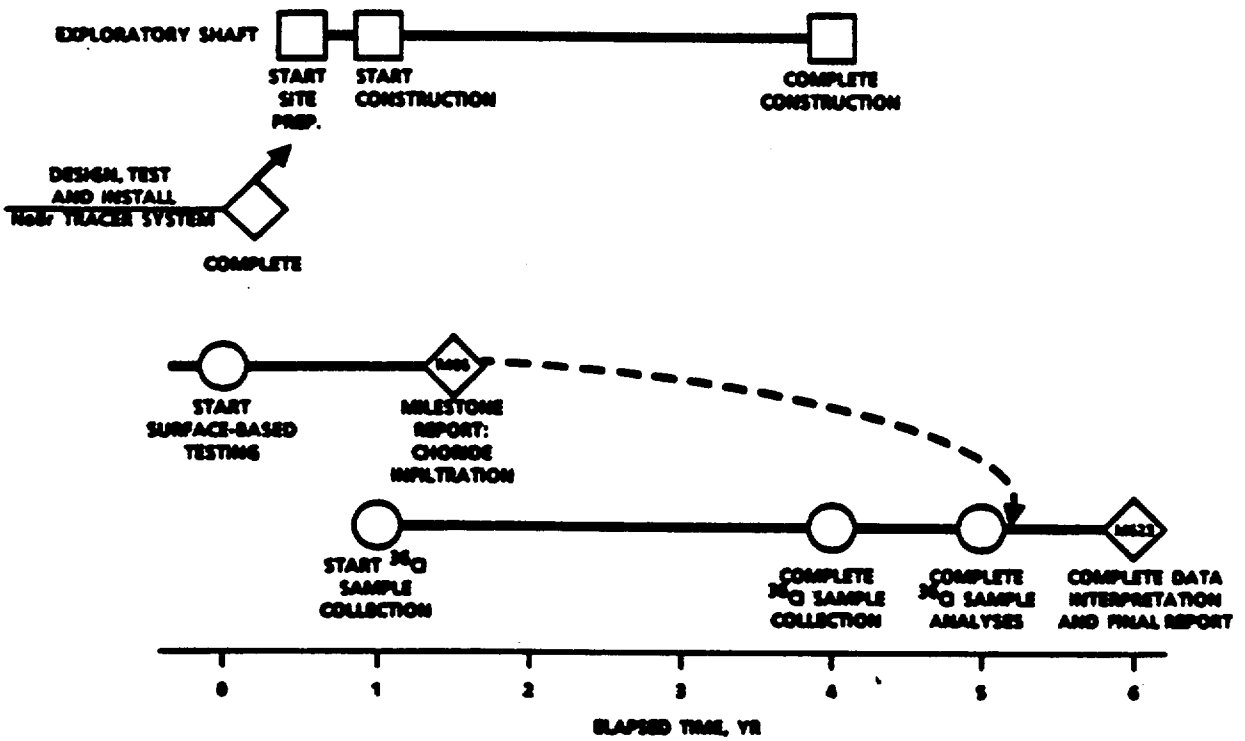

Figure 5. Anticipated Progress in this Study

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APPENDIX A

QUALITY ASSURANCE SUPPORT DOCUMENTATION

Table A-1 lists the applicable NQA-1 criteria for this study and explains how they will be satisfied.

TABLE A-1

APPLICABLE NQA-1 CRITERIA FOR SCP STUDY 8.3.1.2.2
AND HOW THEY WILL BE SATISFIED

NQA-1 Criterion	Documents Addressing These Requirements		Anticipated Date of Issue
1. Organization	The organization of the Office of Civilian Radioactive Waste Management (OCRWM) program is described in Section 8.6 of the SCP. The LANL QA program is described in the LANL-YMP-QAPP and includes a program description addressing each of the NQA-1 criteria. The LANL QA program contains quality administrative procedures (QP) further defining the program requirements.		
	TWS-QAS-QP-01.1	Interface Control	1/31/89
	TWS-QAS-QP-01.2	Stop Work Control	1/31/89
2. QA Program	The LANL QA program is described in the LANL-YMP-QAPP and includes a program description addressing each of the NQA-1 criteria. An overall description of the YMP QA program for site characterization activities is described in Section 8.6 of the SCP.		
	TWS-QAS-QP-02.1	Personnel Certification	1/31/89
	TWS-QAS-QP-02.2	Personnel Training	1/31/89
	TWS-QAS-QP-02.3	Conflict Resolution	1/31/89
	TWS-QAS-QP-02.4	Management Assessment	4/30/89
3. Design and Scientific Investigation Control	This study is a scientific investigation. The following QPs apply:		
	TWS-QAS-QP-03.1	Software QA Plan	4/30/89
	TWS-QAS-QP-03.2	Technical Review	4/30/89
	TWS-QAS-QP-03.3	Scientific Investigation Planning	4/30/89
	TWS-QAS-QP-03.4	Quality Assurance Level Assignment	4/30/89
	TWS-QAS-QP-03.5	R&D Control (Notebooks)	4/30/89
	TWS-QAS-QP-03.6	Design Interface Control	1/31/89
	TWS-QAS-QP-03.7	Peer Review	4/30/89
	TWS-QAS-QP-03.8	Readiness Review	1/31/89
	TWS-QAS-QP-03.9	Scientific Analysis Control	4/30/89

TABLE A-1

APPLICABLE NQA-1 CRITERIA FOR SCP STUDY 8.3.1.2.2
AND HOW THEY WILL BE SATISFIED
(continued)

NQA-1 Criterion	Documents Addressing These Requirements		Anticipated Date of Issue
	TWS-QAS-QP-03.10	Software Documentation and Review	4/30/89
	TWS-QAS-QP-03.11	Software Configuration Management	4/30/89
	TWS-QAS-QP-03.12	Scientific and Engineering Software	4/30/89
	TWS-QAS-QP-03.13	Auxiliary, Commercial and Utility Software	4/30/89
4. Procurement Document Control	TWS-QAS-QP-04.1	Procurement	12/14/88
	TWS-QAS-QP-04.2	Acceptance of Procured Services	1/31/89
	TWS-QAS-QP-04.3	Qualification of Suppliers	1/31/89
5. Instructions, Procedures, and Drawings	TWS-QAS-QP-05.1	Preparation of QPs	12/14/88
	TWS-QAS-QP-05.2	Preparation of DPs	12/14/88
6. Document Control	TWS-QAS-QP-06.1	Controlled Document Distribution	1/31/89
7. Control of Purchased Material, Equipment, and Services	Applicable parts of this criterion are covered in Item 4 (see above).		
8. Identification and Control of Materials, Parts and Samples	TWS-QAS-QP-08.1	Control of Samples	4/30/89
	TWS-QAS-QP-08.2	Control of Data	4/30/89
9. Control of Special Processes	This criterion has been determined to be inapplicable to the scope of work of the LANL YMP.		
10. Inspection	This criterion has been determined to be inapplicable to the scope of work of the LANL YMP.		
11. Test Control	This criterion has been determined to be inapplicable to the scope of work of the LANL YMP.		
12. Control of Measuring and Test Equipment	The control of instrument calibration and data collection is described in the technical procedures referenced in Sections 3.1 through 3.3 of this plan. The following QPs also apply:		

TABLE A-1

APPLICABLE NQA-1 CRITERIA FOR SCP STUDY 8.3.1.2.2
AND HOW THEY WILL BE SATISFIED
(concluded)

NQA-1 Criterion	Documents Addressing These Requirements		Anticipated Date of Issue
	TWS-QAS-QP-12.1	Measuring and Test Equipment	4/30/89
	TWS-QAS-QP-12.2	Control of User Calibrated Equipment	4/30/89
13. Handling, Storage and Shipping	TWS-QAS-QP-13.1	Handling, Shipping, and Storage	4/30/89
14. Inspection, Test and Operating Status	This criterion has been determined to be inapplicable to the scope of work of the LANL YMP.		
15. Nonconforming Materials, Parts or Components	TWS-QAS-QP-15.1	Nonconformances	12/14/88
16. Corrective Action	TWS-QAS-QP-16.1	Corrective Action Control	1/31/89
	TWS-QAS-QP-16.2	Trending	4/30/89
17. Quality Assurance Records	TWS-QAS-QP-17.1	Resident File	12/14/88
	TWS-QAS-QP-17.2	Records Processing Center	12/14/88
18. Audits	TWS-QAS-QP-18.1	Audits	1/31/89
	TWS-QAS-QP-18.2	Surveys	4/30/89
	TWS-QAS-QP-18.3	Auditor/Lead Audit or Cert.	1/31/89

QUALITY ASSURANCE LEVEL ASSIGNMENT SHEET (QALAS)
AND
QUALITY LEVEL ASSIGNMENT CRITERIA SHEET (QLACS)

SIP No. 86/1.2.3.4.1.2

Rev. 0

Activity Natural Isotope Chemistry

Tasks: Chloride and ^{36}Cl Measurements of Infiltration at Yucca Mountain
^{99}Tc Distribution in Soil Relative to ^{36}Cl
Uranium-Series Disequilibrium Feasibility Study

TABLE A-2

QUALITY ASSURANCE LEVEL ASSIGNMENTS FOR STUDY PLAN 8.3.1.2.2.2

NNWSI QUALITY ASSURANCE LEVEL ASSIGNMENT			
Items/Activities	QA Level	QA Requirements	Technical Justification
Chloride and ^{36}Cl Measurements of	I	1,2,3,4,5,6,7,8, 10,11,12,13,15,	NNWSI SPO-02-02: para 5.2.1.b. & d. (activity will provide site
Infiltration at Yucca Mountain		16,17,18. See attached QLACS	characterization and license application data) and Step 2 of
			QA Level Assignment Checklist

APPROVALS (Signature and Date)

PI A. E. Norris Sept. 3, 1986 TPO D. E. Ellis 9.3.86

QAL Suzanne Dey 9/3/86 WMPO (TECH) M Blanchard 9.4.86

QAIM Paul Eisenhauer 9/3/86 WMPO (PQM) James Blaylock 9/4/86

PI FINAL REVIEW A. E. Norris October 9, 1986

QUALITY LEVEL ASSIGNMENT CRITERIA SHEET (QLACS)

SIP No. 86/1.2.3.4.1.2.

Rev. 0

Activity Natural Isotope Chemistry

Task: Chloride and ^{36}Cl Measurements of Infiltration at Yucca Mountain

PI: A. E. Norris

QA Criterion	Applies	Does not Apply	Comments
1. QA Organization	x		
2. QA Program	x		
3. Design and Scientific Investigation Control	x		Only scientific investigation requirements apply
4. Procurement Document Control	x		
5. Instructions, Procedures, and Drawings	x		
6. Document Control	x		
7. Control of Purchased Material, Equipment, and Services	x		
8. ID and Control of Materials, Parts, Components & Samples	x		

QA Criterion	Applies	Does not Apply	Comments
9. Control of Processes		x	Activities performed under this WBS are not considered to be special processes as defined in Appendix A SOP-02-01
10. Inspection	x		Applicable for surveillance requirements only
11. Test and Experiment/ Research Control	x		
12. Control of Measuring and Test Equipment	x		
13. Handling, Shipping, and Storage	x		
14. Inspection, Test, and Operating Status		x	No hardware generated in this task
15. Control of Nonconformances	x		
16. Corrective Action	x		
17. QA Records	x		
18 QA Audits	x		

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