

PROGRESS REPORT #16

APPENDIX B

Regulatory and Management Document Progress

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APPENDIX B

Regulatory and Management Document Progress

This appendix summarizes in tabular form the status of selected important regulatory and management documents related to the Yucca Mountain Site Characterization Project. Progress on each document since the last progress report is described, followed by a forecast of future activity related to that document. Documents discussed include the Mined Geologic Disposal System Requirements Document, the Technical Management Implementation Plan, and the Test and Evaluation Plan. Other requirements documents and management plans are also discussed.

Changes to several documents are on hold pending the completion of the current revision of the Mined Geologic Disposal System Requirements Document. Once Revision 3 of the Mined Geologic Disposal System Requirements Document is approved, several of these documents will be removed from Level 2 Change Control Board control. As listed in this appendix, information reflects the approved versions of documents during the reporting period.

Documents cited in this appendix are included in the consolidated reference list for this progress report (Appendix L).

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Table B-1. Regulatory and Management Document Progress

Document	Progress or Change	Forecast
Regulatory Documents		
<p>Mined Geologic Disposal System Requirements Document (DOE, 1996b)</p>	<p>Revision 3 draft completed to coincide with Revision 3 of the higher level Civilian Radioactive Waste Management Systems Requirements Document, the Technical Baseline Streamlining initiative (BCP 00-96-0009), and the current waste containment and isolation strategy</p>	<p>Complete Revision 3, which includes completion of the Management and Operating Contractor review, submittal to the U.S. Department of Energy for acceptance review, and approval by the Level 2 Change Control Board.</p>
<p>Repository Design Requirements Document (DOE, 1994f)</p>	<p>No change.</p>	<p>After Revision 3 of the Mined Geologic Disposal System Requirements Document is approved, the Repository Design Requirements Document will be removed from Level 2 Change Control Board control.</p>
<p>Engineered Barrier Design Requirements Document (DOE, 1995i)</p>	<p>No change.</p>	<p>After Revision 3 of the Mined Geologic Disposal System Requirements Document is approved, the Engineered Barrier Design Requirements Document will be removed from Level 2 Change Control Board control.</p>
<p>Site Design and Test Requirements Document (DOE, 1995f)</p>	<p>No change.</p>	<p>No revision planned.</p>
<p>Exploratory Studies Facility Design Requirements (DOE, 1996h)</p>	<p>No change.</p>	<p>No revision planned.</p>

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Table B-1. Regulatory and Management Document Progress (continued)

Document	Progress or Change	Forecast
Surface-Based Testing Facilities Requirements Document (DOE, 1996j)	No change.	No revision planned.
Controlled Design Assumptions Document (CRWMS M&O, 1996c)	Revision in process to incorporate key assumptions to support the viability assessment.	Revision planned to incorporate changes to the technical baseline during the last half of fiscal year (FY) 1997.
Site Characterization Program Baseline (DOE, 1995a)	No change. See Appendix H of this progress report for a history of changes to the Site Characterization Program Baseline.	No revision planned.
Management Documents		
Project Management Plan (DOE, 1995k)	No change.	No revision planned.
Environmental Management Plan (DOE, 1993d)	Revision under review.	Review scheduled for completion during FY 1997.
Project Work Breakdown Structure (DOE, 1995m)	Minor changes made to reflect the current Program direction.	No revision planned. Minor changes will be made as necessary during fiscal year planning.
Systems Engineering Management Plan (DOE, 1994i)	No change.	No revision planned.

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Table B-1. Regulatory and Management Document Progress (continued)

Document	Progress or Change	Forecast
Project Test and Evaluation Plan	Developing the Viability Assessment Test and Evaluation Plan, which supports the viability assessment by demonstrating a viable plan to integrate Project testing for all Project test programs as described in the Office of Civilian Radioactive Waste Management (OCRWM) Test and Evaluation Master Plan (Revision 0).	Viability Assessment Test and Evaluation Plan is scheduled for completion at the end of FY 1997.

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Project Change Control Board Actions

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APPENDIX C

Project Change Control Board Actions

This appendix contains a summary of significant Change Control Board actions to the Project Baseline and the Project Cost and Schedule Baseline.

Proposed changes to quality affecting and nonquality affecting documents that are listed in the Change Control Board Register, are submitted using a Change Request in accordance with procedure YAP-3.5Q, Change Control Process. A Change Request is reviewed, and if acceptable in form and content, is processed by Configuration Management, evaluated by the Change Control Board Members, and dispositioned by the Change Control Board Chairperson. A Directive is issued with instructions that the change be implemented by Affected Organizations in accordance with corresponding procedures.

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Cost Schedule and Work Scope Changes

Title	Change Description/Disposition	Status
Initial Baseline for fiscal year (FY) 97 Work Scope for WBS 1.2.1.10	Provided a plan/strategy for inclusion of Plutonium waste forms into Federal Waste Management System.	Closed
Reduce Project Administrative Scope and Budget	Rescheduled and reduced work scope in administrative areas to make budget available for use in technical elements. Scope changes were made at levels below the Planning System Summary Account.	Closed
Viability Assessment Risk Management Plan	Added planning packages for the scopes and budgets that are presented in the Yucca Mountain Site Characterization Project Viability Assessment Risk Mitigation Plan	Closed
Modification of Project Cost and Schedule Baseline	Reconciled the Level II Milestone data with the Level III data in the fiscal year 1997 Project Cost and Schedule Baseline. Also proposed Level 1 Milestone additions and deletions per the Office of Civilian Radioactive Waste Management direction.	Closed
Phase I Planning for the Addition of a New Borehole to the Crest of Yucca Mountain	Provided critical stratigraphic, structural and rock property characteristics data needed to integrate the geologic description of the western block with the description of the geologic system developed from data collected at other areas of the potential repository block.	Closed
Revise Project Cost and Schedule Baseline Document to Multiyear Baseline Configuration (Level 1, Level 2 and Level 3)	Updated the Project Cost and Schedule Baseline to a multiyear configuration with baseline data for Levels 1, 2 and 3.	Closed

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Cost Schedule and Work Scope Changes (continued)

Additional Regulatory Consulting Team Support	Request for funding to enhance the Project's confidence in Licensing strategy and the License Application Plan (one of four key deliverables at viability assessment), as well as other regulatory and technical documents, plans, and strategies.	Open
Web-Based Information System (WBIS) Prototype	Transfer of funds from WBS 1.2.5.X to the Management and Operating Contractor 1.2.5.2.4 for the use of the Hypertext Markup Language (HTML software language on the Project).	Open

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APPENDIX D

Interactions with the U.S. Nuclear Regulatory Commission and Other Organizations

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APPENDIX D

Interactions with the U.S. Nuclear Regulatory Commission and Other Organizations

This appendix documents interactions among the U.S. Department of Energy (DOE) and other organizations associated with the Yucca Mountain Site Characterization Project. Most of these interactions are held for the purpose of communicating with the U.S. Nuclear Regulatory Commission (NRC) or the Nuclear Waste Technical Review Board (NWTRB). Other interested parties, such as the State of Nevada, frequently participate in these interactions with the NRC and the NWTRB.

Appendix D consists of a table presenting interactions that occurred during the six-month reporting period of this progress report, including the following:

- Organization with whom the interaction occurred
- Date of the interaction
- Location of the interaction
- Type of interaction (Technical Exchange, Management Meeting, etc.)
- Short summary of the subject and purpose of each interaction.

Interactions with the U.S. Nuclear Regulatory Commission and Other Organizations

Organization	Date	Type	Location	Subject/Purpose
NRC	10/23/96	Management Meeting	Washington, DC, Rockville, MD, San Antonio, TX, and Las Vegas, NV (video conference)	Provide a forum for DOE and NRC managers to discuss current activities and concerns and resolve identified issues. Discussion topics included an update of the Program plan and budget, the legislative process, an update of Office of Waste Acceptance and Storage and Transportation activities, status of 10 CFR Part 960, an update on DOE documentation of decisions, Seismic Topical Report III, an update of the Licensing Support System, and NRC quality assurance concerns.
NRC	12/16/96	Technical Meeting	Washington, DC and Las Vegas, NV (video conference)	Identify issues, propose resolutions, and resolve issues related to the design, testing, and construction of the Exploratory Studies Facility (ESF).
NRC	1/15/97	Management Meeting	Washington, DC and Las Vegas, NV (video conference)	Provide a forum for DOE and NRC managers to discuss current activities and concerns and resolve identified issues. The purpose of this meeting was for the NRC staff to provide an overview of the NRC High-Level Radioactive Waste Program Annual Report for Fiscal Year 1996 before its distribution.
NRC	2/5/97	Appendix 7 Meeting	Washington, DC	Criticality: Discuss DOE's proposed postclosure disposal criticality analysis methodology, understand and address NRC staff concerns and questions on the methodology and on the Disposal Criticality Analysis Methodology Technical Report, better understand the NRC staff's views on issues regarding the disposal criticality rule, and seek NRC staff feedback the likelihood of acceptance of the planned criticality analysis methodology.

Interactions with the U.S. Nuclear Regulatory Commission and Other Organizations (continued)

Organization	Date	Type	Location	Subject/Purpose
NRC	2/6/97	Appendix 7 Meeting	Rockville, MD	Level of Design Detail: Discuss the design detail for the license application; bring NRC participants up to date on the repository design; provide an overview of the approach the DOE plans to take to determine and develop the appropriate level of design detail for the license application; provide examples of application of that approach; and to seek NRC feedback on the approach.
NRC	2/25-26/97	Technical Exchange	Rockville, MD	Igneous Activity Program: Achieve issue definition on the approach to considering igneous activity in total system performance assessment for the viability assessment and identify areas of agreement and disagreement on the relevant geologic data, the probability of volcanism, models for calculating consequences, and performance assessment models of igneous activity.
NRC	2/27/97	Appendix 7 Meeting	Rockville, MD	Seismic Methodology: Discuss NRC's review comments on DOE's seismic design methodology and revisions to Seismic Topical Report II.
NRC	3/13/97	Technical Meeting	Rockville, MD, San Antonio, TX, and Las Vegas, NV (video conference)	Identify issues, propose resolutions, and resolve issues related to the design, testing, and construction of the ESF.

Interactions with the U.S. Nuclear Regulatory Commission and Other Organizations (continued)

Organization	Date	Type	Location	Subject/Purpose
NRC's Advisory Committee on Nuclear Waste (ACNW)	10/22-23/96	87th ACNW Meeting	Rockville, MD	The agenda for this meeting mostly dealt with ACNW administrative topics, future Committee activities and plans, and preparation of ACNW reports. One topic of interest discussed was the Branch Technical Position on Requirements for Radioactive Waste Land Burial Sites Authorized Under Former 10 CFR 20.302, 20.304 and current 20.2002.
ACNW	11/12-13/96	88th ACNW Meeting	Rockville, MD	To conduct a planning session during which the Committee discussed (a) the conduct of its activities, internal operations and methods for formulating advice; and (b) priority issues for ACNW consideration. The meeting was originally planned as a retreat and thus was primarily concerned with issues internal to the Committee.
ACNW	1/28-30/97	89th ACNW Meeting	Rockville, MD	To discuss possible ACNW reports relevant to Yucca Mountain, including Radionuclide Transport at Yucca Mountain, Critical Group and Reference Biosphere for a Waste Disposal Facility Performance Assessment, and Time of Compliance in Low-Level Waste Disposal. Also discussed were the status of site characterization at the proposed Yucca Mountain repository, status of the NRC staff's efforts to revise 10 CFR Part 60, status of 10 CFR Part 960 options paper, and status of Environmental Protection Agency high-level waste standards.

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Interactions with the U.S. Nuclear Regulatory Commission and Other Organizations (continued)

Organization	Date	Type	Location	Subject/Purpose
ACNW	3/20-21/97	90th ACNW Meeting	Rockville, MD	To discuss the options paper for 10 CFR 960, Siting Guidelines, defense in-depth philosophy, Phase II of the Biosphere Model Validation Study (BIOMOVS II) (NRC presentations); biosphere modeling associated with the International Atomic Energy Agency-sponsored BIOMASS theme (Electric Power Research Institute presentation); ACNW report preparation and development of future meeting agenda. The ACNW met with the NRC directors of the Division of Waste Management and Spent Fuel Projects Office to discuss the division's priorities and highlight issues for ACNW consideration.
NWTRB	10/9-10/96	Full Board Meeting	Arlington, VA	Discussions included the following: an update on Yucca Mountain program and status; status of planning efforts from the long-range plan through license application, including viability assessment, plus fiscal year (FY) 1996 accomplishments and FY 1997 objectives of the unsaturated zone conceptual flow model; sensitivity analyses to evaluate alternative unsaturated zone conceptual flow models and approach to integrate a total system performance assessment with the viability assessment; mined geologic disposal system operations; retrievability issues; waste package physical characteristics; subsurface remote operations and drift stability and maintenance; and an update on the evolution of the program's thermal management strategy. A round-table discussion followed the presentations on the second day and covered topics presented during the meeting.

Interactions with the U.S. Nuclear Regulatory Commission and Other Organizations (continued)

Organization	Date	Type	Location	Subject/Purpose
NWTRB	1/28-29/97	Full Board Meeting	Pahrump, NV	<p>Discussion included the following on total system performance assessment and transportation. Total system performance assessment: DOE's total system performance assessment transparency efforts; NRC on making performance assessments understandable and credible; changes in the French nuclear waste program, and key objectives of their technical program and making them understandable; National Research Council's view of understanding risk; Nevada on the meaning of total system performance assessment to the public. Transportation: DOE's transportation privatization initiative; Nevada's critical transportation issues; affected units of local government on privatization. Additional topics: status of Yucca Mountain program activities; Nevada's concerns with the DOE's proposed new siting guidelines and the viability assessment; DOE's topical safety analysis report on an interim storage facility; saturated zone flow and unsaturated zone/saturated zone transport studies; hydraulic/conservative tracer testing and transport/reactive tracer testing at C-hole complex; flow and transport models; thermal and underground testing; Nye County's technical program; and, DOE's plans to reduce hydrologic uncertainty.</p>

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APPENDIX E

Status of U.S. Nuclear Regulatory Commission Analysis Open Items

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APPENDIX E

Status of U.S. Nuclear Regulatory Commission Site Characterization Analysis Open Items

This appendix documents the resolution status of U.S. Nuclear Regulatory Commission (NRC) concerns as documented in the Site Characterization Analysis (SCA) (NRC, 1989). The SCA documents the NRC staff's concerns resulting from its review of the U.S. Department of Energy (DOE) Site Characterization Plan (DOE, 1988) for Yucca Mountain. The SCA consists of objections, comments, and questions. Open items are objections, comments, and questions that have not yet been resolved. The DOE tracks the status of these open items through closure, as indicated by formal NRC acceptance of DOE's resolution actions.

For each objection, comment, and question, Appendix E provides a short description of the item and its date of closure (if closed). It also briefly describes actions in progress to address the items that are still open.

Status of Site Characterization Analysis Open Items

Item ID	Item Description	Status	Action Description
Objection 1	Adequacy of Title I design control process.	Closed 11/2/92	NRC letter lifting Objection 1. NRC considers this objection closed.
Objection 2	Acceptability of DOE Quality Assurance Program.	Closed 3/2/92	NRC letter lifting Objection 2. NRC considers this objection closed.
Comment 1	A systematic, iterative approach to identify and collect data during site characterization to support a license application not demonstrated to be in place.		Submit a supplemental response to the NRC. This response will be used to close Comments 10, 18, 49, and 60.
Comment 2	Performance Assessment: Confidence in performance.		Submit a supplemental response to the NRC.
Comment 3	Reliance on expert judgment to supply licensing information.		Supplemental response submitted to the NRC on 6/1/95. Awaiting NRC concurrence. Guidance on closure provided by NRC on 12/26/96.
Comment 4	Rationale for the testing needs; integration of testing with design and performance assessment needs.		Develop parametric calculations to refine parameter goals. Develop plans for collecting all necessary data. Supply NRC with the information in semiannual progress reports. Submit a supplemental response to the NRC.
Comment 5	Waste Package: Interpretation of substantially complete containment.	Closed 7/11/94	NRC Evaluation of DOE response. NRC considers this comment closed.
Comment 6	Performance Assessment: Hypothesis Testing Table and alternative conceptual models.		Submit a supplemental response to the NRC.

Status of Site Characterization Analysis Open Items (continued)

Item ID	Item Description	Status	Action Description
Comment 7	Use of expert judgment versus peer review.		Supplemental response submitted to the NRC on 7/12/93. Awaiting NRC concurrence. Guidance on closure provided by NRC on 12/26/96.
Comment 8	Alternative Tectonic Models.		Study Plan 8.3.1.17.4.12, Rev. 1 "Tectonic Models and Synthesis" submitted to the NRC on 12/19/94.
Comment 9	Use of expert judgment during the development of Hypothesis Testing Table.		Submit a supplemental response to the NRC.
Comment 10	Assessment of significance of site hydrologic characteristics.		Resolve concerns in Comment 1. Resolution of Comment 1 will address the cross-issues for this comment.
Comment 11	No hypothesis on the thermal effects of waste emplacement in the hydrologic environments presented.		Submit a supplemental response to the NRC.
Comment 12	Porous flow in the Calico Hills unit.	Closed 11/2/92	NRC letter lifting Objection 1. NRC considers this comment closed.
Comment 13	Surface Hydrology: Surface water gaging station locations and the natural infiltration measurements.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 14	Hydrologic properties of the tuffaceous beds of the Calico Hills nonwelded unit.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.

Status of Site Characterization Analysis Open Items (continued)

Item ID	Item Description	Status	Action Description
Comment 15	Solitario Canyon horizontal borehole activity is inadequate to discriminate between the hypotheses that faults are barriers to fluid flow in non-welded tuff units or faults are conduits for liquid-water flow.	Closed 9/15/94	NRC evaluation of Study Plan 8.3.1.2.2.4. NRC considers this comment closed.
Comment 16	Characterization of the hydrologic properties of the Calico Hills unit.	Closed 11/2/92	NRC letter lifting Objection 1. NRC considers this comment closed.
Comment 17	Multi-purpose borehole testing near the shafts.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 18	Initial hydrologic modeling studies are not supported by planned studies.		Resolve concerns in Comment 1. Resolution of Comment 1 will address cross issues for this comment.
Comment 19	Saturated Zone: Work is not adequate for saturated zone characterization.		Develop and submit plan to define sufficient testing of the saturated zone. Submit a supplemental response to the NRC.
Comment 20	Saturated Zone: Potentiometric surface will not adequately be defined.		Submit a supplemental response to the NRC.
Comment 21	Saturated Zone: technetium-199 and iodine-129 are not included to be characterized in the groundwater flow and radionuclide analysis background concentrations.		Supplemental response submitted to the NRC on 1/7/93. Awaiting NRC concurrence.
Comment 22	Saturated Zone: Hydrochemical samples.		Supplemental response submitted to the NRC on 1/7/93. Awaiting NRC concurrence.

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Status of Site Characterization Analysis Open Items (continued)

Item ID	Item Description	Status	Action Description
Comment 23	Unsaturated Zone: Evaluation of radionuclide concentrations on fracture surfaces.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 24	Approaches are not sufficient for determining reliable thermodynamic properties.		Study Plan and supplemental response sent to NRC on 10/31/96. Awaiting NRC concurrence.
Comment 25	Waste Package: Rationale on additional testing on waste and interactions between and among radionuclides on sorption.		Submit Study Plan 8.3.4.2.4.1 "Characterization of Chemical and Mineralogical Changes in Post-Emplacement Environment" to NRC. Submit a supplemental response to the NRC.
Comment 26	Sorption Batch Studies.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 27	Batch Sorption Measurements.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 28	Sorption on Particulates and Colloids.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 29	Biological Sorption and Transport.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 30	Solubility Modeling.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 31	Some parameters and conditions under fracture flow are not planned and need to be determined.		Supplemental response sent to the NRC on 10/29/96. Awaiting NRC concurrence.

Status of Site Characterization Analysis Open Items (continued)

Item ID	Item Description	Status	Action Description
Comment 32	Rock characteristics program: Geophysical integration is insufficient.		Geophysical Integration Group needs to develop a plan to implement integration. Submit a supplemental response to the NRC.
Comment 33	Engineering rock parameters are not adequately integrated to develop three-dimensional rock characteristics models.		Study Plan 8.3.1.4.3.1 "Systematic Acquisition of Site Specific Data" submitted to the NRC on 1/11/93. Study Plan 8.3.1.4.2.3 "Three-Dimensional Geologic Modeling" and supplemental response submitted to the NRC on 9/27/96. Awaiting NRC response.
Comment 34	Drilling Program: It is unclear how data from various drill holes will be used in support of various studies, how uncertainties in core retrieval and data analyses will be handled, and how the large volume of existing information will be used to plan the drilling program.		Supplemental response submitted to the NRC on 3/3/92. Awaiting NRC concurrence.
Comment 35	Adequacy of lithological, structural, and drifting activities to characterize the site.	Closed 11/2/92	NRC letter lifting Objection 1. NRC considers this comment closed.
Comment 36	Rationale for Investigation 8.3.1.4.2 may not be accurate for the perimeter drift defining lower concentrations of faults.		Supplemental response submitted to the NRC on 6/16/94. Awaiting NRC concurrence.
Comment 37	Identification of blast fractures.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 38	Characterization of faults in the subsurface.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.

Status of Site Characterization Analysis Open Items (continued)

Item ID	Item Description	Status	Action Description
Comment 39	Systematic Drilling Program: No assessment is provided to support the estimated maximum range of statistical correlation for porosity and air permeability.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 40	Systematic Drilling Program: Spacing of the 30 sample borehole pairs in a range of up to 10,000 feet may represent a lower bound for geostatistical analysis.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 41	Systematic Drilling Program: Tight clustering of sample locations USW SD-8 and USW SD-12 has not been justified.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 42	Adequacy of evaluation of escarpment retreat.	Closed 2/29/96	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 43	Adequacy of numerical goals in erosion, postclosure tectonics, and preclosure tectonics performance assessment tables.	Closed 2/17/95	NRC evaluation of the 7/23/92 DOE supplemental response provided in 2/17/95 letter from Bell to Milner. NRC considers this comment closed.
Comment 44	Waste Package: Overall goal is not consistent with substantially complete containment.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 45	Volcanic rate calculations independent of underlying volcanic-tectonic processes.		Supplemental response submitted to the NRC on 7/12/93. Awaiting NRC concurrence.

Status of Site Characterization Analysis Open Items (continued)

Item ID	Item Description	Status	Action Description
Comment 46	Postclosure Tectonics.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 47	Waste Package: Relationship of postclosure tectonics to the waste package and the engineering barrier system requirements.		Supplemental response submitted to the NRC on 6/9/93. Awaiting NRC concurrence.
Comment 48	Use of fault slip rates on the repository facilities are not conservative.		Prepare and issue topical report "Seismic Design Criteria" in accordance with the Seismic Hazards Issue Resolution Group's Issue Resolution Action Plan. Submit a supplemental response to the NRC.
Comment 49	Volcanism: Results from investigations on basaltic volcanism may fail to meet overall system performance.	Closed 9/14/94	NRC evaluation of Study Plan 8.3.1.8.1.2. NRC considers this comment closed.
Comment 50	Effects of faulting may be underestimated.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers the comment closed.
Comment 51	Adequacy of Geophysics program to determine deep and shallow crustal features.		Geophysical Integration group needs to develop a plan to implement integration.
Comment 52	Use of Geophysics to identify volcanic/igneous features.		Completed assessment by independent consultant of planned and potential geophysical studies that contribute to resolution of volcanism issue. Consultant's preliminary findings were submitted to the NRC on site representative. Submit a supplemental response to the NRC.

Status of Site Characterization Analysis Open Items (continued)

Item ID	Item Description	Status	Action Description
Comment 53	Adequacy of natural resource assessment; consideration of ore deposition models.		Supplemental response submitted to the NRC on 2/5/93 in Study Plan 8.3.1.9.2.1. NRC Letter 2/18/94 Holonich to Shelor partially closing Site Characterization Analysis Comment 53. Supplemental response submitted to the NRC on 10/07/94. Awaiting NRC concurrence.
Comment 54	Inconsistencies in Site Characterization Plan Chapter 8.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 55	Adequacy of geostatistical approach to geomechanical and thermal properties.		Study Plan 8.3.1.15.1.3, Rev. 1, "Rock Characteristics Program," submitted to the NRC on 6/5/95. Supplemental response submitted to the NRC 9/23/96 recommending closure of this comment. Awaiting NRC concurrence.
Comment 56	Validation of models for mechanical and thermal properties.		Submitted SP 8.3.1.15.1.5, Rev. 1 "Excavation Investigations," to NRC on 5/5/94. Submit 8.3.1.15.1.6 "In Situ Thermomechanical Properties," and 8.3.1.15.1.7, "In Situ Mechanical Properties" to the NRC. The Review of Performance Allocations for Activity 8.3.1.15 "Rock Characteristics Program" needs to be completed. Submit a supplemental response to the NRC.
Comment 57	Design verification does not consider alternative methods of excavation.	Closed 11/2/92	NRC letter lifting Objection 1. NRC considers comment closed.
Comment 58	Descriptions in the in situ design verification section do not include tests to verify design reports.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.

Status of Site Characterization Analysis Open Items (continued)

Item ID	Item Description	Status	Action Description
Comment 59	Description of tectonic and igneous events do not allow for determination of actual investigations to be conducted, and sequencing of activities.		Submit a supplemental response to the NRC.
Comment 60	Performance Assessment: Adequacy of preclosure design and performance goals and characterization parameters.		Resolve concerns in Comment 1. Resolution of Comment 1 will address cross-issues of this comment.
Comment 61	Assumption that future faulting will follow previous faulting.		Submit a supplemental response to the NRC.
Comment 62	The studies of faulting at the surface facilities do not indicate how DOE is proposing to use standoff distances.		Submit a supplemental response to the NRC.
Comment 63	Use of pre-existing and unavailable information for the preclosure tectonics program and the surface facilities.		Submit a supplemental response to the NRC which will describe where in the study plan and the "Test and Evaluation Plan" the concerns of the NRC are addressed.
Comment 64	Adequacy of faults study for design and performance.		Submit a supplemental response to the NRC.
Comment 65	Use of domains to define areas of faulting potential	Closed 7/31/96	NRC evaluation of DOE response. NRC considers this comment closed.

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Status of Site Characterization Analysis Open Items (continued)

Item ID	Item Description	Status	Action Description
Comment 66	Release via a single event 10,000 year cumulative slip earthquake.		Complete detailed study to show the facility can conservatively withstand an event exceeding the design basis ground motion. Submit a supplemental response to the NRC.
Comment 67	Data on earthquakes having a cutoff of a magnitude 5.5 may not be sufficient to support an evaluation of the effects of site geology on surface and subsurface motion.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 68	Adequacy of treatment on detachment faulting effects.		Study Plan 8.3.1.17.4.12, Rev. 1 "Tectonic Models and Synthesis" submitted to the NRC on 12/19/94. Awaiting NRC concurrence.
Comment 69	Synthesis of data on the northwest trending faulting.		Study Plan 8.3.1.17.4.12 "Tectonic Models and Synthesis" submitted to the NRC on 12/19/94.
Comment 70	Blast control procedures less important to post-closure performance are not justified.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 71	Adequacy of technologies in assessing faulting for construction, operation, and closure.		Submit a supplemental response to the NRC.
Comment 72	Adequacy of the seal program.	Closed 11/2/92	NRC letter lifting Objection 1. NRC considers this comment closed.

Status of Site Characterization Analysis Open Items (continued)

Item ID	Item Description	Status	Action Description
Comment 73	Performance Assessment: Adequacy of required backfill hydraulic conductivity.		Resume work on the seals program investigation. Prepare the study plan for the measurement of the hydraulic conductivity (currently no numeric designator for this study plan). Submit a supplemental response to the NRC.
Comment 74	Testing of Seal Components: No indication is given as to whether and when the testing to evaluate the behavior of selected sealing components under in situ test conditions will be initiated.		Prepare Study Plan 8.3.3.2.2.3 "In Situ Testing of Seal Components." Submit a supplemental response to the NRC.
Comment 75	Definition of and inconsistent use of geologic setting.	Closed 12/30/93	NRC Evaluation of DOE Responses. NRC considers this comment closed.
Comment 76	NRC reviews cannot be relied on as peer reviews.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 77	Adequacy of considerations of retrieval operations in evaluating the effects of credible accidents on radiological exposure.		Evaluate the effects of credible accidents on radiological exposures during retrieval operation of the Advanced Conceptual Design. Submit a supplemental response to the NRC.
Comment 78	10 CFR Part 20 requirements need to be considered for postclosure.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.

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Status of Site Characterization Analysis Open Items (continued)

Item ID	Item Description	Status	Action Description
Comment 79	Waste Package: Adequacy of waste package corrosion tests for the repository.		<p>Complete the reviews and revisions of Study Plan 8.3.4.2.4.1 "Characterization of Chemical and Mineralogical Changes in the Post Emplacement Environment" and submit to the NRC.</p> <p>The Lawrence Livermore National Laboratory report, "Metal Barrier Selection and Testing," LLNL SIP CM-01, Rev. 2 was submitted to the NRC on 1/31/95.</p> <p>Submit a supplemental response to the NRC.</p>
Comment 80	Performance goals consistent with interpretation and intent of substantially complete containment.	Closed 3/7/95	NRC Evaluation of the 9/20/94 supplemental response. NRC considers this item closed.
Comment 81	Waste Package: Adequacy of program in stress corrosion cracking behavior of waste packages.		<p>The metals barriers scientific investigation plan was submitted to the NRC on 1/31/95.</p> <p>Evaluation of the extended dry concept with drift emplacement needs to be completed which may make this concern moot.</p> <p>The metals barrier scientific investigation must be initiated and preliminary results released.</p> <p>Submit a supplemental response to the NRC.</p>
Comment 82	Waste Package: There is an inadequate discussion on how the waste package performance may be verified at the time of license application.		<p>Prepare Study Plan 8.3.4.2.4.4 "Engineered Barrier System Field Test" and submit to the NRC.</p> <p>Submit a supplemental response to the NRC.</p>
Comment 83	The term "uniform corrosion" is misleading.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.

Status of Site Characterization Analysis Open Items (continued)

Item ID	Item Description	Status	Action Description
Comment 84	Issue resolution strategy and testing package for the waste package and engineering barrier system do not take into account the full range of likely natural conditions that might affect performance of the barrier.		Consider the effect of unanticipated processes and events on the overall system in the ongoing issue resolution process. Submit a supplemental response to the NRC.
Comment 85	Performance Assessment: Temporal changes in the state of stress due to corrosion of the container is not accounted for.		The metals barriers scientific investigation plan to be completed. Evaluation of the extended dry concept with drift emplacement needs to be completed which may make this concern moot. The metals barrier scientific investigation must be initiated and preliminary results released. Submit a supplemental response to the NRC.
Comment 86	Waste Package: Degradation modes of copper-based alloys do not appear to agree with scientific literature.		Complete the degradation modes surveys for candidate materials and test plans for promising materials. Submit a supplemental response to the NRC.
Comment 87	Waste Package: Adequacy of effects of dissimilar metal contacts causing corrosion.		Advance the waste package design that will narrow the waste package option down to three designs. Describe the use of data from galvanic testing in the waste package design plan. Submit a supplemental response to the NRC.
Comment 88	Waste Package: Assumption of reduced uncertainties because of the unsaturated zone.		The Lawrence Livermore National Laboratory scientific investigation SIP-CM-01 (Rev. 1), "Metal Barrier Selection and Testing" was submitted to the NRC on 1/31/95. Awaiting NRC concurrence.

Status of Site Characterization Analysis Open Items (continued)

Item ID	Item Description	Status	Action Description
Comment 89	Waste Package: Construction materials may change the local pH and affect the corrosion of the metal containers and the leach rates of radionuclides from the glass.		Prepare Study Plan 8.3.4.2.4.5 "Manmade Materials" and submit to the NRC. Submit a supplemental response to the NRC.
Comment 90	Waste Package: Consideration of varying oxygen concentrations on the corrosion of metal containers.		Provide details on how the effects of oxygen on the waste package will be considered. These details will be described in the metal barriers investigation plan. Complete evaluation of the drift emplacement alternative. This alternative would make this concern moot. Submit a supplemental response to the NRC.
Comment 91	Waste Package/Performance Assessment: Consideration of alternative canisters for carbon-14 releases.		Evaluate and describe performance of alternative waste package designs to be considered in advanced conceptual design. Review the new U.S. Environmental Protection Agency standards when they become available. Alternative waste package scenarios need to be developed. A robust design may make this concern moot. Submit a supplemental response to the NRC.
Comment 92	Disturbed Zone: Boundary definition does not include properties affected by heat generated by waste emplacement.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 93	Performance Assessment: Will the site meet the performance objective for prewaste emplacement.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.

Status of Site Characterization Analysis Open Items (continued)

Item ID	Item Description	Status	Action Description
Comment 94	Performance Assessment: Assumption about features, events, processes related to the hydraulic systems in the modeling strategy.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 95	Performance Assessment: Logic used to develop and screen scenarios and its implementation appear to be deficient.		NRC evaluation of DOE response (Letter Austin to Milner; 3/28/96) NRC considers this comment open.
Comment 96	Adequacy of the use of Kd for modeling heterogeneous medium.		Study Plans 8.3.1.3.4.1 "Sorption Study" and 8.3.1.3.4.3 "Development of Sorption Models" were submitted to the NRC on 8/26/94; Study Plan 8.3.1.3.5.1 "Dissolved Species Concentration Limit" was submitted to the NRC on 9/17/93. Submit a supplemental response to the NRC.
Comment 97	Adequacy of evidence to eliminate iodine as an important radionuclide.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 98	Performance Assessment: Appropriateness of weighting Complementary Cumulative Distribution Functions by expert judgment.		Continue the development of the alternative conceptual models. Address the complementary cumulative distribution functions through the iterative total system performance assessment (TSPA) process. Prepare and provide the NRC with documentation on the TSPA and sensitivity studies (related to schedule in Comment 9). Submit a supplemental response to the NRC.
Comment 99	Performance Assessment: Quantification of all releases.		Supplemental response submitted to the NRC on 8/4/94. Awaiting NRC concurrence.

Status of Site Characterization Analysis Open Items (continued)

Item ID	Item Description	Status	Action Description
Comment 100	Performance Assessment: Adequacy of considerations of faulting release scenarios.	Closed 2/8/93	NRC evaluation of DOE responses. The NRC considers this comment closed.
Comment 101	Performance Assessment: Appropriateness of equation used to estimate the partial performance for the 4th scenario class involving release along the water pathway.	Closed 3/28/96	NRC evaluation of DOE Responses. The NRC considers this comment closed.
Comment 102	Performance Assessment: Adequacy of Ross sequences in comparison to the hydrologic flow model.		Supplemental response submitted to the NRC on 8/4/94. Awaiting NRC concurrence.
Comment 103	Performance Assessment: Ross sequences address anticipated conditions and not scenarios.	Closed 3/28/96	NRC evaluation of DOE Responses. The NRC considers this comment closed.
Comment 104	Performance Assessment: Ross sequences address spent fuel but not vitrified waste form.	Closed 2/8/93	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 105	Performance Assessment: Rationale for elimination of scenarios.		NRC evaluation of DOE responses (Letter Austin to Milner 3/28/96) NRC considers this comment open.
Comment 106	Performance Assessment: Missing coupling term for calculation of liquid phase radionuclide transport.	Closed 2/8/93	NRC evaluation of DOE responses. NRC considers this comment closed.

Status of Site Characterization Analysis Open Items (continued)

Item ID	Item Description	Status	Action Description
Comment 107	Performance Assessment: Awaiting time in calculation is OK but care needs to be taken in the empirical complementary cumulative distribution functions in approximating.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 108	Performance Assessment: Use of the estimated partial performance measures to screen scenarios and establish goals.	Closed 2/8/93	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 109	Performance Assessment: Adequacy of treatment of coupling time between matrix and fracture flow in hypothesis testing tables.		Continue total system performance analysis activity that will continue to analyze the coupling times for the transfer of radionuclides between matrix and fracture flow. Submit a supplemental response to the NRC.
Comment 110	Performance Assessment: Adequacy of dealing with human intrusion in the complementary cumulative distribution function.	Closed 2/8/93	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 111	Inconsistencies exist in the Site Characterization Plan on total system performance.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 112	Adequate discussion of state variables as constants or as random variables.	Closed 2/8/93	NRC evaluation of DOE responses. NRC considers this comment closed.

Status of Site Characterization Analysis Open Items (continued)

Item ID	Item Description	Status	Action Description
Comment 113	Consistency of definition of complementary cumulative distribution function and the unit step function.	Closed 2/8/93	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 114	The term "independent" is used instead of "mutually exclusive."	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 115	Adequacy of expanding of complementary cumulative distribution function in terms of scenario classes.	Closed 3/28/96	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 116	Individual exposures via potable water may need to be expanded.		Issuance by the U.S. Environmental Protection Agency of a new Yucca Mountain-specific standard (40 CFR Part 197) for individual exposure standards per the Energy Policy Act of 1992. Revise issue resolution strategy for Site Characterization Plan Issue 1.2. Prepare additional response to NRC. Submit revised issue resolution strategy and response to NRC.
Comment 117	Individual exposure rate of carbon-14 may need to consider advective and diffusive flow rates.		Submit a supplemental response to the NRC.
Comment 118	The monitoring and testing activities should include long-term in situ and long-term waste package activities.		Determine testing requirements after site characteristics have advanced far enough to define the performance program. Submit a supplemental response to the NRC.

Status of Site Characterization Analysis Open Items (continued)

Item ID	Item Description	Status	Action Description
Comment 119	Performance Confirmation: The information presented is insufficient to determine if the confirmation program meets the requirements of 10 CFR Part 60.		Conduct NRC-DOE interaction on the performance confirmation program. Prepare Study Plan 8.3.3.2.2.3 "In Situ Testing of Seal Components" and then submit to the NRC for acceptance. Prepare Study Plan 8.3.1.15.1.6 "In Situ Thermomechanical Properties" and submit to the NRC. Prepare Study Plan 8.3.4.2.4.4 "Engineered Barrier Field Tests" and submit to the NRC. Submit a supplemental response to the NRC.
Comment 120	Model and computer code validation studies.		Prepare and provide to the NRC the model and computer code validation strategy. Submit a supplemental response to the NRC.
Comment 121	Exploratory Shaft Facility: Adequacy of seismic design of Exploratory Shaft Facility.		Exploratory Studies Facility Design Requirements submitted on 9/9/94. Awaiting NRC concurrence.
Comment 122	Demonstration and acceptability of the dry coring method.		Supplemental response submitted to the NRC on 3/30/94. Awaiting NRC concurrence.
Comment 123	Assessment of effects of ventilation on the Exploratory Shaft Facility.	Closed 6/21/94	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 124	Potential causes for a reduction in the drainage capacity.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 125	Existing data used in the licensing process needs to be qualified.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 126	Items covered by 10 CFR Part 60 (G) are incomplete.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.

Status of Site Characterization Analysis Open Items (continued)

Item ID	Item Description	Status	Action Description
Comment 127	Design Acceptability Analysis.	Closed 11/2/92	NRC letter lifting Objection 1. NRC considers this comment closed.
Comment 128	Requirements applicable to the Exploratory Shaft Facility.	Closed 11/2/92	NRC letter lifting Objection 1. NRC considers this comment closed.
Comment 129	Design Acceptability Analysis and the Exploratory Studies Facility Design Requirements do not consider 10 CFR Part 60 requirements.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 130	Only 22 of fifty-two (52) requirements applicable to the Exploratory Shaft Facility were focused on in the Title I design. The rigor and completeness of the Design Acceptability Analysis are questioned.		Supplemental response submitted to the NRC on 3/3/92. Additional supplemental response submitted to the NRC on 9/25/96. Awaiting NRC concurrence.
Comment 131	Design Acceptability Analysis.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.
Comment 132	Design Acceptability Analysis.	Closed 11/2/92	NRC letter lifting Objection 1. NRC considers this comment closed.
Comment 133	Design Acceptability Analysis.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this comment closed.
Question 1	Integration of mapping efforts.	Closed 12/30/93	NRC evaluation of DOE responses. NRC considers this question closed.

Status of Site Characterization Analysis Open Items (continued)

Item ID	Item Description	Status	Action Description
Question 2	Performance Assessment: Relation between mechanical and hydraulic apertures.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this question closed.
Question 3	Repository Design: Rationale used for selecting the total repository area is not presented.		Supplemental response submitted to the NRC on 5/17/94. Awaiting NRC concurrence.
Question 4	Adequacy of temperature logging to evaluate anomalously low heat flow.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this question closed.
Question 5	Adequacy of vertical boreholes for evaluation of faults and fractures.		Submitted supplemental response to the NRC on 6/16/94. Awaiting NRC concurrence.
Question 6	Meaning of statement in last paragraph page 8.3.1-75.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this question closed.
Question 7	Face mapping of exploratory drifts restricted to areas of anomalous conditions.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this question closed.
Question 8	Rock Properties: Level of detail and uncertainty in three-dimensional model.		Submitted Study Plan 8.3.1.4.3.1 "Systematic Acquisition of Site-Specific Subsurface Information" to the NRC for review on 1/19/93. Submit Study Plan 8.3.1.4.3.2 "Three-Dimensional Rock Characteristics Models" to the NRC for review. Submit a supplemental response to the NRC.
Question 9	Systematic Drilling Program: Adequacy of sampling same sequences for rock properties.		Submitted Study Plan 8.3.1.4.3.1 "Systematic Acquisition of Site-Specific Subsurface Information" to the NRC for review on 1/19/93. Submit a supplemental response to the NRC.

Status of Site Characterization Analysis Open Items (continued)

Item ID	Item Description	Status	Action Description
Question 10	How will three-dimensional block model account for variability in the block?	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this question closed.
Question 11	Rationale to start drilling prior to approval of study plans.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this question closed.
Question 12	Rationale for exclusion of lunar crater basaltic field as natural analog.		Submitted supplemental response to the NRC on 6/9/93. Awaiting NRC concurrence.
Question 13	Basis for statements made about the migration, structural boundaries, and stage of volcanism.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this question closed.
Question 14	Natural Resources: Adequacy of evaluation of previous mining and drilling leases.	Closed 2/18/94	NRC evaluation of DOE responses. NRC considers this question closed.
Question 15	Resource exploration and mineral resource potential.	Closed 2/18/94	NRC evaluation of DOE responses. NRC considers this question closed.
Question 16	Methods for determining the impact of ground motion from underground nuclear explosions.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this question closed.
Question 17	Rock Properties: Activities to investigate effects on.	Closed 4/21/93	NRC evaluation of DOE responses. NRC considers this question closed.
Question 18	Allowable movements on joints related to rock mass strength.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this question closed.
Question 19	Side Looking Airborne Radar (SLAR).	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this question closed.

Status of Site Characterization Analysis Open Items (continued)

Item ID	Item Description	Status	Action Description
Question 20	Repository Design: Discussion of vertical or horizontal emplacement.		Supplemental response submitted to the NRC on 6/16/94. Awaiting NRC concurrence.
Question 21	Process to assure the parameters for performance goal C2 (radiation shielding of rock) is comprehensive enough, and expected values, realistic.		Further develop the advanced conceptual design. Submit a supplemental response to the NRC.
Question 22	Parameters related to repository construction and operation.		Supplemental response submitted to the NRC on 3/30/94. Awaiting NRC concurrence.
Question 23	Computer code verification and validation.		Submit a supplemental response to the NRC.
Question 24	Justification that the shaft liner does not provide structural support for the formation.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this question closed.
Question 25	Heterogeneous air flow characteristics for seal program.		Supplemental response submitted to the NRC on 4/13/93. Awaiting NRC concurrence.
Question 26	Inconsistency between tentative Design Goals and Design Performance Goals.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this question closed.
Question 27	Storage capacity at base of shaft for attaining the tentative design goals.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this question closed.
Question 28	ES-1 penetration of the Calico Hills Unit: Impacts of the current sealing program and issue resolution strategy 4.4.		Supplemental response submitted to the NRC on 3/3/92. Awaiting NRC concurrence.

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Status of Site Characterization Analysis Open Items (continued)

Item ID	Item Description	Status	Action Description
Question 29	Justification that references cited present results representative of conditions at Yucca Mountain.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this question closed.
Question 30	Waste Package: Water quality as related to waste package design.		The metal barriers scientific investigation plan was submitted to the NRC on 1/31/95. Complete evaluation of the drift emplacement alternative needs. Submit a supplemental response to the NRC.
Question 31	Waste Package: Integrity of spent fuel cladding.		Supplemental response submitted to the NRC on 9/16/92. Awaiting NRC concurrence.
Question 32	Waste package: Container "similarity" for borosilicate glass waste vs. spent fuel.		Advance the waste package design and narrow the waste package options down to three designs. Submit a supplemental response to the NRC.
Question 33	Waste Package: Emplacement hole drainage concerns.		Evaluate water-vapor interface, crevice corrosion, and galvanic corrosion testing in the metal barriers scientific investigation plan during advanced conceptual design. Complete evaluation of the drift emplacement alternative. This alternative would make this concern moot. Submit a supplemental response to the NRC.
Question 34	Waste Package/Performance Assessment: Meaning of undetected defective closures.		Submit a supplemental response to the NRC.
Question 35	Waste Package: Acceptance criteria for helium leak results.	Closed 3/7/95	NRC Staff evaluation of the 12/02/94 supplemental response. NRC considers this item closed.

Status of Site Characterization Analysis Open Items (continued)

Item ID	Item Description	Status	Action Description
Question 36	Waste Package: Contact of canisters with corrosive elements during shipping and handling.		Advance the waste package design and narrow options down to three designs. Submit a supplemental response which will further address the issue of eliminating corrosion elements during manufacture of the container to the NRC.
Question 37	Waste package: Basis for 10 cm of free fall for canister and contents.	Closed 3/7/95	NRC evaluation of the 11/23/94 supplemental response. NRC considers this question closed.
Question 38	What is the basis for the 1-mm thinning criterion for waste package scratching.		Submitted a supplemental response to the NRC on 7/12/93. Awaiting NRC concurrence.
Question 39	Waste Package: Defining "unusual process history" of canister.		Advance the design of the waste package. Submit a supplemental response to the NRC.
Question 40	Waste Package: Basis for factor of 2 on borehole liner in comparison to container material.		Study effects of water containing liner corrosion products on degradation of the container in accordance with the metal barriers scientific investigation plan. Submit a supplemental response to the NRC.
Question 41	Repository: Consideration of 10 CFR 60.132 (a) in resolution of Issue 2.4.		Conduct engineering studies to evaluate the waste throughput requirements. Submit a supplemental response to the NRC.
Question 42	Repository: Assumption of stability of vertical emplacement hole.		Advance the advanced conceptual design. Drift emplacement may make this comment moot. Submit a supplemental response to the NRC.
Question 43	Waste Package: Anticipated operational occurrences considered part of normal conditions on the preclosure design and analysis.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this question closed.

Status of Site Characterization Analysis Open Items (continued)

Item ID	Item Description	Status	Action Description
Question 44	Waste Package/Performance Assessment: Basis for assumed numbers of breached assemblies or canisters.		Provide information on failures of waste forms in multiple locations. Prepare and provide the NRC with documentation on the Total System Performance Assessment. Advance the Advanced Conceptual Design and narrow options to two candidate designs. Submit a supplemental response to the NRC.
Question 45	Waste Package: Investigation of particulate source terms, retention factors, and plate-out of waste package during accident conditions.		Supplemental response submitted to the NRC on 11/8/94. Awaiting NRC concurrence.
Question 46	Waste Package: Basis for stricter containment of long half-life isotopes.	Closed 7/11/94	NRC evaluation of DOE response. NRC considers this question closed.
Question 47	Waste Package: Assumption on breached waste containers.	Closed 3/7/95	NRC evaluation of the 9/20/94 supplemental response. NRC considers this question closed.
Question 48	Waste Package: Selection of peer review panel on waste package.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this question closed.
Question 49	Waste Package: Effects of low temperature oxidation on containers.		Advance the design of the waste package to three options. The metal barriers scientific investigation plan was submitted to the NRC on 1/31/95.
Question 50	Waste Package: Assumption that stress propagation results in corrosion.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this question closed.

Status of Site Characterization Analysis Open Items (continued)

Item ID	Item Description	Status	Action Description
Question 51	Design second research criteria for accepting waste from Idaho National Engineering Laboratory and Hanford.	Closed 11/8/94	NRC evaluation of DOE responses. NRC considers this question closed.
Question 52	Waste Package: Leaching properties specification will require the producer to control leaching characteristics of the glass waste.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this question closed.
Question 53	Waste Package: Specification of cooling rate of the glass waste.	Closed 3/7/95	NRC evaluation of the 10/07/94 supplemental response. NRC considers this question closed.
Question 54	Waste Package: Release rates of radionuclides from spent fuels.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this question closed.
Question 55	Exploratory Shaft Facility: Interference at the Exploratory Shaft Facility by waste storage tanks, septic field, and waste water lagoon.		Submit a supplemental response to the NRC.
Question 56	Basis for 5 cm of fault displacement in waste package environment.		Supplemental response submitted to the NRC on 5/17/94. Awaiting NRC concurrence.
Question 57	Effects of drilling multipurpose boreholes.		Supplemental response submitted to the NRC on 3/24/93. Awaiting NRC concurrence.
Question 58	Flexibility of the Exploratory Shaft Facility design to accommodate in situ testing of the waste package, if required.		Supplemental response submitted to the NRC on 1/31/94. Awaiting NRC concurrence.

Status of Site Characterization Analysis Open Items (continued)

Item ID	Item Description	Status	Action Description
Question 59	Basis for length of in situ thermal tests.		Prepare Study Plan 8.3.1.15.1.6 "In Situ Thermomechanical Properties" and submit to NRC. Submit a supplemental response to the NRC.
Question 60	Exploratory Shaft Facility: Timing of Exploratory Shaft Facility radial borehole test.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this question closed.
Question 61	Exploratory Shaft Facility: Accommodation of design changes during Exploratory Shaft Facility construction.	Closed 11/2/92	NRC letter lifting Objection 1. NRC considers this question closed.
Question 62	Repository: Basis for 500 feet of separation from Exploratory Shaft Facility and waste emplacement panel.		Submit a supplemental response to the NRC.
Question 63	Certifying Training Attendance Record reviewers were not principal investigators.	Closed 7/31/91	NRC evaluation of DOE responses. NRC considers this question closed.

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APPENDIX F

Determination of Importance Evaluations

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APPENDIX F

Determination of Importance Evaluations

This appendix lists determination of importance evaluations performed during this reporting period. Performance of a determination of importance evaluation is the mechanism established by the Project to evaluate proposed field activities with respect to their potential for adverse impact on Q-List (DOE, 1997b) items or site characterization testing. Because the natural barriers are included in the Q-List, each determination of importance evaluation essentially comprises both a waste isolation evaluation and a test interference evaluation for the proposed activity. Where a reasonable potential for adverse impact is identified, the evaluation establishes appropriate quality assurance (QA) controls for the activity to prevent or limit the adverse impact. These controls are then transcribed into the applicable documents for implementing the activity; for example, field work packages, design packages, specifications, and drawings.

The determination of importance evaluation process is controlled by an Implementing Line Procedure. Provision for a determination of importance evaluation is an integral part of the planning process for all site-disturbing activities, including testing activities as well as design and construction activities. Temporary, non-quality-affecting items are evaluated to the extent that their placement, construction/erection, or operation/utilization presents a potential for adverse impact on Q-List items or site characterization testing. Any proposed use of tracers, fluids, or materials is specifically required to be evaluated. The safety assurance department, which prepares determination of importance evaluations, receives requests for evaluations of site-disturbing activities from all Project participants.

The determination of importance procedure (NLP-2.0, Determination of Importance Evaluations) provides for flexibility in evaluating site impacts through the use of category definitions. Category I evaluations are for activities that would not reasonably impact Q-List items or site characterization testing. Category II evaluations are for activities where the potential impacts are encompassed by existing evaluations such that no new QA controls are warranted. Category III evaluations are used for activities that present a potential for adverse impact, but have not been previously evaluated. Category III determination of importance evaluations establish new QA controls for those activities as required.

Documents cited in this appendix are included in the consolidated reference list for this progress report (Appendix L).

The following determination of importance evaluations and revisions were completed or substantially completed during this reporting period.

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Exploratory Studies Facility (ESF) Determination of Importance Evaluations

- **Category II Determination of Importance Evaluation for Testing in the ESF Thermal Testing Facility Heated Drift, (CRWMS M&O, 1996ii):** This evaluation was prepared to support testing activities to be performed in the Thermal Testing Facility for the drift-scale heater test. Water use associated with the wet drilling of boreholes needed for equipment and test instrumentation emplacement was included in the evaluation. The evaluation concluded that one additional site-specific QA control was warranted to clarify existing requirements as applied to this specific activity, and that the activity was otherwise bounded by the conclusions contained in the existing **Category III Determination of Importance Evaluation for the Subsurface ESF (CRWMS M&O, 1997v)**. Thus, the site-specific control contained in this determination of importance evaluation, coupled with the requirements contained in the existing **Category III Determination of Importance Evaluation for the Subsurface ESF**, are adequate to limit any potential for adverse test interference or waste isolation impacts.
- **Revision to the Category II Determination of Importance Evaluation for Testing in the ESF Thermal Testing Facility Heated Drift (CRWMS M&O, 1996ii):** This revision incorporated the proposed addition of a concrete liner (to be tested), a concrete invert floor (to facilitate testing), and a thermal bulkhead in the heated drift of the Thermal Testing Facility, and the actual heating of the heated drift. The evaluation concluded that one additional site-specific QA control was warranted to clarify existing requirements as applied to this specific activity, and that the activity was otherwise bounded by the conclusions contained in the existing **Category III Determination of Importance Evaluation for the Subsurface ESF (CRWMS M&O, 1997v)**. Thus, the site-specific control contained in this determination of importance evaluation, coupled with the requirements contained in the existing **Category III Determination of Importance Evaluation for the Subsurface ESF**, are adequate to limit any potential for adverse test interference or waste isolation impacts.
- **Revision to the Category II Determination of Importance Evaluation for Phase I Testing in the Topopah Spring Main Drift Thermal Testing Facility (CRWMS M&O, 1996jj):** This revision revised the scope of the evaluation to remove testing activities associated with the sequential drift mining of the access and observation drift of the Thermal Testing Facility such that water used to drill boreholes beyond the location of the thermal-mechanical alcove could be more suitably evaluated as a part of the larger heated-drift test block. The conclusions of the evaluation were unchanged; i.e., that the existing **Category III Determination of Importance Evaluation for the Subsurface ESF (CRWMS M&O, 1997v)** contains adequate QA controls to limit any potential for adverse test interference or waste isolation impacts.
- **Revision to the Category III Determination of Importance Evaluation for the Subsurface ESF (CRWMS M&O, 1997v):** This revision was prepared primarily to incorporate recent changes to the subsurface hydrologic water model and to address water reporting in the subsurface ESF after holeout of the tunnel boring machine. Numerous other

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changes were made to the evaluation, including the incorporation of five existing Category II determination of importance evaluations. The overall conclusions of the evaluation remained unchanged, and there were only minor changes to the QA controls required to prevent or minimize test interference and waste isolation impacts.

- Revision to the Category III Determination of Importance Evaluation for the Surface ESF (CRWMS M&O, 1997v): This revision was prepared to revise the evaluation of reclamation materials to consider biodegradability; to prohibit the use of a particular dust suppression compound within the Conceptual Controlled Area Boundary without additional evaluation (required because of a recent change to the main chemical constituent of this compound); to make changes to the text as appropriate based on a review of the use of certain words having precise definitions within the argot of the Project's QA Program (e.g., "surveillance," "inspection," "monitoring"); to update references as appropriate; and to make various minor editorial, grammatical, and/or typographical changes throughout. The overall conclusions of the evaluation remained unchanged, and there were only minor changes to the QA controls required to prevent or minimize test interference and waste isolation impacts.
- Category II Determination of Importance Evaluation for Confirmation Drilling in the Exploratory Studies Facility (CRWMS M&O, 1997x): This evaluation addressed the drilling of two boreholes in the left rib of Alcove #1. One was to be drilled wet and the second to be drilled dry. The evaluation concluded that the existing Category III Determination of Importance Evaluation for the Subsurface ESF (CRWMS M&O, 1997v) contains adequate QA controls to limit any potential for adverse test interference or waste isolation impacts.
- Category II Determination of Importance Evaluation for the ESF Drift-Scale Flux and Niche Study (CRWMS M&O, 1997y): This evaluation was prepared to support the construction of two niches to be excavated in the west (right) rib of the main drift of the Topopah Spring loop and subsequent hydrology testing to be performed in the niches. The evaluation indicates that additional site-specific QA controls are warranted to clarify existing requirements as applied to these specific activities and that the activities are otherwise bounded by the conclusions contained in the existing Category III Determination of Importance Evaluation for the Subsurface ESF (CRWMS M&O, 1997v). Thus, the site-specific controls contained in this determination of importance evaluation, coupled with the requirements contained in the existing Category III Determination of Importance Evaluation for the Subsurface ESF, are adequate to limit any potential for adverse test interference or waste isolation impacts.

Surface-Based Testing Determination of Importance Evaluations

- Revision to the Category I Determination of Importance Evaluation for Remote Surface Seismic Monitoring of the ESF (CRWMS M&O, 1996kk): This revision was prepared to reflect a change in the planned location for one of the monitoring activities to be performed by Sandia National Laboratories and to add a new Los Alamos National

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Laboratory monitoring activity involving the installation of seven seismometers and two magnetometers at eight sites. The conclusions of the evaluation remained unchanged (i.e., that the activities are limited in scope and duration such that the disturbances are negligible and that no impacts to waste isolation or site characterization activities are expected).

- Revision to the Category II Determination of Importance Evaluation for Yucca Mountain Site Characterization Project Surface-Based Testing Reclamation Activities (CRWMS M&O, 1997z): This revision added interim reclamation activities to the scope of the evaluation, evaluated activities more generally with respect to their proposed physical location (inside or outside of the Test and Waste Isolation Evaluation Zone), and updated references as appropriate. The issuance of this revision supported the timely commencement of certain interim reclamation activities being conducted in Midway Valley. The "window" for performing those activities was of a limited duration, such that any delay in starting the work could not have been accommodated (the work would have to have been postponed for at least one year, and possibly for up to five years). The evaluation concluded that the existing Category III Determination of Importance Evaluation for the Surface ESF (CRWMS M&O, 1997aa) contains adequate QA controls to limit any potential for adverse test interference or waste isolation impacts.

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APPENDIX G

Study Plan Status

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APPENDIX G

Study Plan Status

This appendix shows the completion and review status of each study plan. Study plans are the means chosen to describe test plans, the methods to be used, the results expected, and how the results will be applied. They are the control mechanisms for the investigations that make up the site characterization program.

Information presented in Appendix G includes the study plan number and title, as well as the following dates:

- Date of submittal to the Yucca Mountain Site Characterization Office
- Date of approval by the Yucca Mountain Site Characterization Office
- Date of completion of U.S. Nuclear Regulatory Commission initial review with no objections
- Date of receipt of comments from the State of Nevada.

Study Plan Status

Study Plan Number	Study Plan Title	Submitted to YMSCO ^a	Approved by YMSCO ^b	Reviewed by NRC ^c	Reviewed by NV ^d
8.3.1.2.1.1	Characterization of the Meteorology for Regional Hydrology	6/26/90	3/13/91	10/21/91	12/10/91
8.3.1.2.1.2	Characterization of Runoff and Streamflow	3/27/89	8/21/90	5/14/91	4/12/91
8.3.1.2.1.3	Characterization of the Regional Ground-Water Flow System	3/1/90	1/18/91	10/4/91	3/19/93
8.3.1.2.1.4	Regional Hydrologic System Synthesis and Modeling	6/6/90	12/18/91	5/6/92	1/29/93
8.3.1.2.2.1	Characterization of Unsaturated-Zone Infiltration	3/9/90	1/18/91	5/31/91	
8.3.1.2.2.2, R0	Water Movement Test	9/23/87	11/9/89	4/8/93	
8.3.1.2.2.2, R1	Water Movement Test	10/17/91	2/10/93	4/8/93	
8.3.1.2.2.3	Characterization of Percolation in the Unsaturated Zone—Surface-Based Study	8/12/88	4/8/91	3/26/92	
8.3.1.2.2.4	Characterization of the Yucca Mountain Unsaturated Zone in the Exploratory Studies Facility (.4, .5, .7, .8, .9)	9/9/87	1/9/89	3/5/93	
8.3.1.2.2.4, R1	Characterization of the Yucca Mountain Unsaturated Zone in the Exploratory Studies Facility (.4, .5, .7, .8)	12/4/92	1/14/93	3/5/93	
8.3.1.2.2.4, R2	Characterization of the Yucca Mountain Unsaturated Zone in the Exploratory Studies Facility (.10)	3/16/93	6/2/94	9/15/94	
8.3.1.2.2.4, R3	Characterization of the Yucca Mountain Unsaturated Zone in the Exploratory Studies Facility (.1, .2)	4/29/94	5/15/96		
8.3.1.2.2.5	Diffusion Tests in the Exploratory Studies Facility	11/1/88	4/22/92	1/19/93	11/1/93

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Study Plan Status (continued)

Study Plan Number	Study Plan Title	Submitted to YMSCO ^a	Approved by YMSCO ^b	Reviewed by NRC ^c	Reviewed by NV ^d
8.3.1.2.2.5, R1	Diffusion Tests in the Exploratory Studies Facility	5/19/95	Waiting on Principal Investigator's revisions		
8.3.1.2.2.6	Characterization of Gaseous-Phase Movement in the Unsaturated Zone	6/12/89	6/11/91	10/7/91	5/1/92
8.3.1.2.2.6, R1	Characterization of Gaseous-Phase Movement in the Unsaturated Zone	4/6/93	9/30/93		
8.3.1.2.2.7	Hydrochemical Characterization of the Unsaturated Zone	10/24/88	9/18/90	5/1/92	12/28/92
8.3.1.2.2.7, R1	Hydrochemical Characterization of the Unsaturated Zone	12/1/92	9/9/93	1/26/94	
8.3.1.2.2.8	Fluid Flow in Unsaturated, Fractured Rock	9/7/90	8/12/92	1/28/93	
8.3.1.2.2.8, R1	Fluid Flow in Unsaturated, Fractured Rock	12/1/92	12/17/93	8/23/94	
8.3.1.2.2.9	Site Unsaturated-Zone Modeling and Synthesis	1/25/91	7/1/93	11/8/93	
8.3.1.2.3.1.1-6	Characterization of the Site Saturated-Zone Ground-Water Flow System	5/31/89	2/13/91	12/6/91	
8.3.1.2.3.1.7	Characterization of the Site Saturated-Zone Ground-Water Flow System	2/8/88	2/22/90	12/6/91	
8.3.1.2.3.2	Characterization of the Saturated-Zone Hydrochemistry	3/28/90	4/22/92	1/4/93	

Study Plan Status (continued)

Study Plan Number	Study Plan Title	Submitted to YMSCO ^a	Approved by YMSCO ^b	Reviewed by NRC ^c	Reviewed by NV ^d
8.3.1.2.3.3	Saturated-Zone Hydrologic System Synthesis and Modeling	9/4/90	1/14/93	6/16/93	
8.3.1.3.1.1	Ground-Water Chemistry Model	3/15/91	5/4/94		
8.3.1.3.2.1	Mineralogy, Petrology, and Chemistry of Transport Pathway	1/22/88	6/13/89	8/20/90	12/28/92
8.3.1.3.2.2	History of Mineralogical and Geochemical Alteration of Yucca Mountain	3/28/88	12/18/91	4/27/92	1/24/94
8.3.1.3.3.1	Natural Analog of Hydrothermal Systems in Tuff	No study plan to be developed, overlaps planned activities in Study Plans 8.3.4.2.4.1 and 8.3.1.20.1.1			
8.3.1.3.3.2	Kinetics and Thermodynamics of Mineral Evolution	3/25/94	10/23/96		
8.3.1.3.3.3	Conceptual Model of Mineral Evolution	Combined with Study Plan 8.3.1.3.3.2			
8.3.1.3.4.1	Batch Sorption Studies	10/28/92	8/4/94		
8.3.1.3.4.2	Biological Sorption and Transport	12/12/88	11/25/92	3/25/93	
8.3.1.3.4.3	Development of Sorption Models	Combined with Study Plan 8.3.1.3.4.1			
8.3.1.3.5.1/2	Dissolved Species Concentration Limits and Colloid Behavior (8.3.1.3.5.1 and 8.3.1.3.5.2 have been combined)	9/7/90	9/9/93		
8.3.1.3.6.1	Dynamic Transport Column Experiments	3/10/93	9/30/96		
8.3.1.3.6.2	Diffusion	7/24/89	8/6/93	1/19/94	
3.7.1	Retardation Sensitivity Analysis	12/14/88	8/11/92	1/19/93	

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Study Plan Status (continued)

Study Plan Number	Study Plan Title	Submitted to YMSCO ^a	Approved by YMSCO ^b	Reviewed by NRC ^c	Reviewed by NV ^d
8.3.1.3.7.2	Demonstration of Applicability of Laboratory Data to Repository Transport Calculations	Out year – under development			
8.3.1.3.8.1	Gaseous Radionuclide Transport Calculations and Measurements	No study plan to be developed Work Scope covered under Study Plan 8.3.1.2.2.6 and Activity 8.3.1.3.7.1.3.			
8.3.1.4.2.1	Characterization of the Vertical and Lateral Distribution of Stratigraphic Units Within the Site Area	4/12/90	6/9/92	12/14/92	
8.3.1.4.2.2	Characterization of the Structural Features Within the Site Area	9/4/87	2/3/89	2/8/93	
8.3.1.4.2.2, R1	Characterization of the Structural Features Within the Site Area (.3, .5)	2/27/90	4/22/92	2/8/93	
8.3.1.4.2.2, R2	Characterization of the Structural Features Within the Site Area (.3, .5)	11/18/92	12/22/92	2/8/93	2/11/94
8.3.1.4.2.3	Three-Dimensional Geologic Model	2/13/95	9/19/96		
8.3.1.4.3.1	Systematic Acquisition of Site-Specific Subsurface Information	3/27/90	12/8/92	7/19/93	
8.3.1.4.3.2	Three-Dimensional Rock Characteristics Models	5/4/94	9/18/95		
8.3.1.5.1.1	Characterization of Modern Regional Climate	6/24/93	7/25/94		
8.3.1.5.1.2	Paleoclimate Study: Lake, Playa, and Marsh Deposits	10/25/90	10/31/91	4/27/92	1/24/94
8.3.1.5.1.3	Climatic Implications of Terrestrial Paleoecology	2/11/91	1/17/92	8/27/92	1/24/94

Study Plan Status (continued)

Study Plan Number	Study Plan Title	Submitted to YMSCO ^a	Approved by YMSCO ^b	Reviewed by NRC ^c	Reviewed by NV ^d
8.3.1.5.1.4	Analysis of the Paleoenvironmental History of the Yucca Mountain Region	3/30/90	5/29/91	12/06/91	1/11/93
8.3.1.5.1.5	Paleoclimate-Paleoenvironmental Synthesis	2/2/95	3/15/96		
8.3.1.5.1.6	Characterization of the Future Regional Climate and Environments	12/29/93	6/15/94	10/18/94	
8.3.1.5.2.1	Characterization of the Quaternary Regional Hydrology (.3, .4, .5)	1/26/88	6/8/89	11/24/89	4/9/91
8.3.1.5.2.1, R2	Characterization of the Quaternary Regional Hydrology (.1)	9/25/90	11/10/92	6/24/93	11/1/93
8.3.1.5.2.2	Characterization of Future Regional Hydrology Due to Climate Changes	1/16/91	11/10/92	4/5/93	11/1/93
8.3.1.6.1.1	Distribution and Characteristics of Present and Past Erosion	No study plans to be developed, superseded by the Erosion Topical Report			
8.3.1.6.2.1	Influence of Future Climatic Conditions on Locations and Rates of Erosion				
8.3.1.6.3.1	Evaluation of the Effects of Future Tectonic Activity on Erosion at Yucca Mountain				
8.3.1.6.4.1	Development of a Topical Report on the Effects of Erosion				
8.3.1.8.1.1	Probability of Magmatic Disruption of the Repository	3/29/89	9/19/90	10/5/91	8/8/91
8.3.1.8.1.1, R3	Probability of Magmatic Disruption of the Repository	11/16/95	5/15/96		

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Study Plan Status (continued)

Study Plan Number	Study Plan Title	Submitted to YMSCO ^a	Approved by YMSCO ^b	Reviewed by NRC ^c	Reviewed by NV ^d
8.3.1.8.1.2	Physical Processes of Magmatism and Effects on the Repository	10/21/92	9/21/93	9/14/94	
8.3.1.8.2.1	Analysis of Waste Package Rupture Due to Tectonic Processes and Events	12/15/89	11/16/92	11/19/93	
8.3.1.8.2.1, R1	Tectonic Effects: Evaluations of Changes in the Natural and Engineered Barrier Systems Resulting from Tectonic Processes and Events	2/18/94	5/9/96		
8.3.1.8.3.1	Analysis of the Effects of Tectonic Processes and Events on Average Percolation Flux Rates Over the Repository	These studies have been combined into 8.3.1.8.2.1 R1			
8.3.1.8.3.2	Analysis of the Effects of Tectonic Processes and Events on Changes in Water-Table Elevation				
8.3.1.8.3.3	Analysis of the Effects of Tectonic Processes and Events on Local Fracture Permeability and Effective Porosity				
8.3.1.8.4.1	Analysis of the Effects of Tectonic Processes and Events on Rock Geochemical Properties				
8.3.1.8.5.1	Characterization of Volcanic Features	12/14/88	4/18/90	8/20/90	2/21/91
8.3.1.8.5.2	Characterization of Igneous Intrusive Features	10/13/92	3/7/94	8/22/94	

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Study Plan Status (continued)

Study Plan Number	Study Plan Title	Submitted to YMSCO ^a	Approved by YMSCO ^b	Reviewed by NRC ^c	Reviewed by NV ^d
8.3.1.8.5.3	Investigation of Folds in Miocene and Younger Rocks of the Region	No study plan to be developed			
8.3.1.9.1.1	An Evaluation of Natural Processes that Could Affect the Long-Term Survivability of the Surface Marker System at Yucca Mountain				
8.3.1.9.2.1	Natural Resource Assessment of Yucca Mountain, Nye County, Nevada	7/13/90	11/6/92	3/16/93	2/11/94
8.3.1.9.2.2	Water Resource Assessment of Yucca Mountain, Nevada	10/6/89	8/26/91	5/4/92	12/28/92
8.3.1.9.3.1	Evaluation of Data Needed to Support an Assessment of the Likelihood of Future Inadvertent Human Intrusion at Yucca Mountain as a Result of Exploration and/or Extraction of Natural Resources	No study plans to be developed			
8.3.1.9.3.2	An Evaluation of the Potential Effects of Exploration for, or Extraction of, Natural Resources on the Hydrologic Characteristics at Yucca Mountain				
8.3.1.12.2.1	Meteorological Data Collection at the Yucca Mountain Site	9/28/90	3/20/91	11/12/91	12/2/91
8.3.1.12.2.1, R1	Meteorological Data Collection at the Yucca Mountain Site	3/31/92	8/9/93		
8.3.1.12.2.1, R2	Meteorological Data Collection at the Yucca Mountain Site	5/20/96	7/1/96		
8.3.1.14.2	Studies to Provide Soil/Rock Properties of Potential Locations of Surface/Subsurface Facilities	7/15/91	10/01/91	1/24/92	4/6/92

Study Plan Status (continued)

Study Plan Number	Study Plan Title	Submitted to YMSCO ^a	Approved by YMSCO ^b	Reviewed by NRC ^c	Reviewed by NV ^d
8.3.1.15.1.1	Laboratory Thermal Properties	3/17/88	10/21/90	8/22/94	
8.3.1.15.1.1, R1	Laboratory Thermal Properties	11/3/92	8/27/93	8/22/94	
8.3.1.15.1.2	Laboratory Thermal Expansion Testing	12/1/88	8/21/90	8/22/94	
8.3.1.15.1.2, R1	Laboratory Thermal Expansion Testing	11/3/92	8/27/93	8/22/94	
8.3.1.15.1.3	Laboratory Determination of Mechanical Properties of Intact Rock	2/8/88	5/21/91	Deferred	
8.3.1.15.1.3, R1	Laboratory Determination of Mechanical Properties of Intact Rock	7/19/93	5/15/95		
8.3.1.15.1.4	Laboratory Determination of the Mechanical Properties of Fractures	10/23/91	12/14/94		
8.3.1.15.1.5	Excavation Investigations	3/26/87	1/09/89	8/19/94	
8.3.1.15.1.5, R1	Excavation Investigations	3/18/93	4/22/94	8/19/94	
8.3.1.15.1.6	In Situ Thermomechanical Properties	1/5/96	5/9/96		
8.3.1.15.1.7	In Situ Mechanical Properties	2/1/96	7/19/96		
8.3.1.15.1.8	In Situ Design Verification	3/20/90	2/3/93	4/15/93	11/1/93
8.3.1.15.2.1	Characterization of the Site Ambient Stress Conditions(.2)	9/22/87	1/11/89	Deferred	
8.3.1.15.2.1, R.1	Characterization of the Site Ambient Stress Conditions(.1)				
8.3.1.15.2.2	Characterization of the Site Ambient Thermal Conditions	10/13/92	6/23/94		

Study Plan Status (continued)

Study Plan Number	Study Plan Title	Submitted to YMSCO ^a	Approved by YMSCO ^b	Reviewed by NRC ^c	Reviewed by NV ^d
8.3.1.16.1.1	Characterization of Flood Potential of the Yucca Mountain Site	3/30/89	9/17/90	5/8/91	1/22/91
8.3.1.16.2.1	Location of Adequate Water Supply for Construction, Operation, Closure, and Decommissioning of a Mined Geologic Disposal System at Yucca Mountain, Nevada	No study plan to be developed			
8.3.1.16.3.1	Determination of the Preclosure Hydrologic Conditions of the Unsaturated Zone at Yucca Mountain, Nevada	No study plan to be developed			
8.3.1.17.1.1	Potential for Ash Fall at the Site	No study plan to be developed			
8.3.1.17.2.1	Faulting Potential at the Repository	No study plan to be developed, combined with Study Plan 8.3.1.17.3.6.			
8.3.1.17.3.1	Relevant Earthquake Sources	8/1/90	12/18/91	5/18/92	1/13/93
8.3.1.17.3.1, R1	Relevant Earthquake Sources	2/18/94	5/15/96		
8.3.1.17.3.2	Underground Nuclear Explosion Sources	All activities rely on available data and are completed.			
8.3.1.17.3.3.1	Ground Motion from Regional Earthquakes	4/21/94	4/24/95		
8.3.1.17.3.3.2	Ground Motion from Underground Nuclear Explosions	2/2/94	9/6/94	12/22/94	
8.3.1.17.3.4	Effects of Local Site Geology on Surface and Subsurface Motions	7/6/90	11/14/91	6/8/92	1/11/93
8.3.1.17.3.5	Ground Motion at the Site from Controlling Seismic Events	10/4/90	7/9/93	11/2/93	
17.3.6	Probabilistic Seismic Hazards Analyses	10/17/94	4/12/95		

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Study Plan Status (continued)

Study Plan Number	Study Plan Title	Submitted to YMSCO ^a	Approved by YMSCO ^b	Reviewed by NRC ^c	Reviewed by NV ^d
8.3.1.17.4.1	Historical and Current Seismicity	10/17/89	9/17/90	5/14/91	11/1/93
8.3.1.17.4.1, R1	Historical and Current Seismicity	11/16/93	11/9/94	2/17/95	
8.3.1.17.4.2	Location and Recency of Faulting Near the Prospective Surface Facilities	12/6/88	5/22/89	11/24/89	5/20/90
8.3.1.17.4.3	Quaternary Faulting Within 100 km of Yucca Mountain, Including the Walker Lane	3/25/92	1/21/93	9/2/93	3/3/94
8.3.1.17.4.4	Quaternary Faulting Proximal to the Site Within Northeast-Trending Fault Zones	8/3/92	3/18/93	9/2/93	
8.3.1.17.4.5	Detachment Faults at or Proximal to Yucca Mountain	5/1/90	7/20/92	2/1/93	1/24/94
8.3.1.17.4.6	Quaternary Faulting Within the Site Area	10/14/88	1/23/91	10/3/91	1/13/93
8.3.1.17.4.7	Subsurface Geometry and Concealed Extensions of Quaternary Faults at Yucca Mountain	No study plan to be developed, scope transferred to Study Plans 8.3.1.4.2.1 and 8.3.1.17.3.6			
8.3.1.17.4.8	Stress Field Within and Proximal to the Site Area	Cancelled. Scope transferred to Study Plan 8.3.1.17.4.12			
8.3.1.17.4.9	Tectonic Geomorphology of the Yucca Mountain Region	No study plan to be developed, scope transferred to Study Plans 8.3.1.5.1.4, 8.3.1.17.4.3, and 8.3.1.17.4.2			
8.3.1.17.4.10	Geodetic Leveling	3/30/90	1/18/91	10/4/91	2/1/93
8.3.1.17.4.11	Characterization of Regional Lateral Crustal Movement	No study plan to be developed, all activities were transferred to Study Plan 8.3.1.17.4.10			
8.3.1.17.4.12	Tectonic Models and Synthesis	4/30/93	11/18/94	2/6/95	

Study Plan Status (continued)

Study Plan Number	Study Plan Title	Submitted to YMSCO ^a	Approved by YMSCO ^b	Reviewed by NRC ^c	Reviewed by NV ^d
8.3.1.17.4.12, R1	Tectonic Models and Synthesis	4/13/95	6/13/95		
8.3.1.20.1.1	Characterization of the Altered Zone	1/30/95			
8.3.3.2.2.1	Seal Material Properties Development	2/2/96	8/9/96		
8.3.3.2.2.3	In Situ Testing of Seal Components	9/16/94	7/19/96		
8.3.4.2.4.1	Characterization of the Chemical and Mineral Changes in the Postemplacement Environment	8/8/94	in review		
8.3.4.2.4.2	Hydrological Properties of Waste Package Environment	12/20/93	2/27/95		
8.3.4.2.4.2, R1	Hydrological Properties of Waste Package Environment	2/28/95	9/27/96		
8.3.4.2.4.3	Characterization of the Geomechanical Attributes for the Waste Package Environment	6/28/89	12/11/92	4/21/93	
8.3.4.2.4.4	Engineered Barrier System Field Tests	7/9/93	10/17/95		
8.3.4.2.4.5	Effects of Man-Made Materials on Water Chemistry	4/28/94	in review		

^aSubmitted to Yucca Mountain Site Characterization Office (YMSCO) and under review.

^bCompleted YMSCO review.

^cCompleted U.S. Nuclear Regulatory Commission (NRC) initial review with no objections.

^dReceived comments from State of Nevada.

^eR0, R1, etc., indicate revision number.

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APPENDIX H

Site Characterization Program Baseline History

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APPENDIX H

Site Characterization Program Baseline History

This appendix discusses revisions that have been made to the Site Characterization Program Baseline. The baseline document provides the Program baseline against which changes to the plans for characterizing the Yucca Mountain site are documented. The baseline document also provides the objectives of each Site Characterization Plan study and information on test controls and testing constraints applicable to the Exploratory Studies Facility.

The following table shows the revision number of each of the 13 revisions that have been made to the Baseline and the date the revision was issued. The table also describes the scope and nature of each revision.

Site Characterization Program Baseline History

Revision	Issued	Revisions
0	2/22/91	Initial Issue
1	4/5/91	Updated information related to the Exploratory Studies Facility (ESF). Incorporated changes to program planning resulting from the "Exploratory Studies Facility Alternatives Study: Final Report."
2	10/2/91	Revised plans for testing in Site Characterization Plan Section 8.3.1.14. Consolidated all the expected studies under Investigation 8.3.1.14 into one Study Plan (8.3.1.14.2).
3	2/7/92	Changes to the objectives of Activities 1 and 4 in Study Plan 8.3.1.2.1.4 and Activity 4 in Study Plan 8.3.1.2.3.2. Added three drillholes to Study Plan 8.3.1.2.3.1. Deleted requirement for tagging surface dust suppression water with chemical tracer.
4	3/13/92	Incorporated changes in the objectives of Activities 1 and 3 in Study Plan 8.3.1.2.3.2.
5	7/15/92	Corrected references to integration of geophysical activities.
6	7/15/92	Updated Section 8.4 to be consistent with current Exploratory Studies Facility concept.
7	7/15/92	Deleted Activity 8.3.1.4.2.1.6 to eliminate redundancy.
8	9/24/92	Reorganized waste package near-field environment program.
9	10/2/92	Changed scope of the Site Characterization Program Baseline to delete activity descriptions that are controlled in the study plans; placed parameter tables in separate controlled document; removed hypothesis testing tables and analyses supporting test control from the Site Characterization Program Baseline. Changes made to Activities 8.3.1.2.2.4.6, 8.3.1.5.2.1.2, 8.3.1.5.2.2.1, 8.3.1.5.2.2.2, 8.3.1.5.2.2.3; changes made to Studies 8.3.1.3.7.2, 8.3.1.8.1.1, 8.3.1.8.1.2, 1.10.4.3; and changes made to Investigation 8.3.1.7.1.
10	1/14/93	Documented changes made to Study 8.3.1.2.2.4; Activities 8.3.1.8.5.2.2, 8.3.1.15.2.2, 8.3.1.17.4.3.2, 8.3.1.17.4.4.3; and Section 8.3.5.13.

Site Characterization Program Baseline History (continued)

Revision	Issued	Revisions
11	8/3/94	Combined studies 8.3.1.8.2.1, 8.3.1.8.3.1, 8.3.1.8.3.2, 8.3.1.8.3.3, 8.3.1.8.4.1 within the postclosure tectonics program into one study (8.3.1.8.2.1, Revision 1). Activity 8.3.1.8.5.2.1 was deleted because data was too ambiguous and too general to be useful. Changed Activity 8.3.1.17.3.1.
12	1/20/95	Revision to Studies 8.3.1.5.1.6 and 8.3.1.15.1.1, editorial changes to Section 8.4 that responded to comments from the U.S. Nuclear Regulatory Commission. Incorporation of revised ESF/Repository interface drawings.
13	3/30/95	Removed the test objectives that were duplicated in the Site Design and Test Requirements Document and updated the design summary to reflect current terminology.

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APPENDIX I

Tables of Technical Computer Codes

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APPENDIX I

Tables of Technical Computer Codes

This appendix lists computer codes that have been used, are being used, or could be used for design analysis, process control, scientific investigation, preclosure and postclosure performance assessments, and other technical activities.

Table I-1 lists the computer code names, including currently used or the most recent versions, a brief statement of the processes being modeled, past, current or potential applications in the Project, and references for documentation required for the approval of the computer code in accordance with the Quality Assurance Requirements and Description (DOE, 1997b). References for applications of the computer codes are not listed. Computer codes that currently meet the requirements of the Quality Assurance Requirements and Description are marked with an asterisk (*).

Table I-2 lists sections of Progress Report #16 where activities are described that identify the computer codes listed in Table I-1. To establish a one-to-one correspondence between these two tables, all computer codes listed in Table I-1 are also listed in Table I-2. Some report sections may not have identified the specific computer codes, however, that were used for the activities described.

In both tables, the names that have been added since Progress Report #15 are in bold type. No computer codes were deleted since Progress Report #15.

Only brief descriptions and captions are given for each computer code in Tables I-1 and I-2. Although this may give the appearance that some computer codes have the same capabilities, each computer code has unique capabilities needed for specific purposes. The distinctive capabilities of each computer code are evident from the references listed in Table I-1 and from the applications summarized in the progress report sections identified in Table I-2.

The appendix does not list computer software for support functions, such as operating systems, administrative and management software, system utilities, compilers and their associated libraries, word processors, spreadsheet programs, data base managers, graphing and visual display systems, statistical analysis tools, and software that is acquired or developed as an integral part of measuring and test equipment. An exception is made (i.e., software listed), if the support software has to meet the requirements of the Quality Assurance and Description because of the nature of its use in technical analyses.

Documents cited in this appendix are included in the consolidated reference list for this progress report (Appendix L).

Table I-1. Analytical Techniques

Names added since Progress Report #15 are in bold type. No computer codes were deleted, but some versions were retired.

* = one or more versions approved for work subject to the Quality Assurance Requirements and Description

See end of table for list of abbreviations and acronyms.

Name	Process	YMP Applications	Status
3DEC* Vs. 1.5* Sep 94	Three-dimensional analysis of underground opening stability and ground motion for jointed rock masses; distinct element method	ESF and repository excavation stability analyses	User's manual (Itasca, 1994a), vs. 1.5 qualification (CRWMS M&O, 1994c); maintained by Itasca Consulting Group, Inc.
ABAQUS Vs. N/A 1982	Soil and rock mechanics analysis	Geomechanical behavior of large-block test and ESF drift-scale test	Example problems manual (Hibbitt, 1982); maintained by Hibbitt, Karlsson and Sorenson, Inc.
ANSYS* Vs. 5.1 Sep 94 Vs. 5.1HP* Jul 95 Vs. 5.2 Aug 95 Vs. 5.2SGI*Feb 97 Vs. 5.3 1996 Vs. 5.4 1996	Multi-dimensional thermal-mechanical analysis of stress, strain, and heat conduction and radiation in solids; includes design optimization; finite element method	Thermal-mechanical analyses in support of waste package development, including the multi-purpose canister; thermal, mechanical, and seismic analysis in support of repository design	Vs. 5.1 user's manual (ANSYS, 1994a), vs. 5.1 verification (ANSYS, 1994b), vs. 5.1HP qualification (CRWMS M&O, 1995h), vs. 5.2SGI qualification (CRWMS M&O, 1997bb); newer user's manuals on CD-ROM; maintained by ANSYS, Inc.
AREST Vs. 1.0 Nov 93	Radionuclide release from waste package and engineered barrier system	Engineered barrier system performance analysis in support of total system performance assessments	Theory (Liebetau et al., 1987; Engel and McGrail, 1993), user's manual (Buxbaum and Engel, 1991); software requirements Engel et al., 1993); maintained at Pacific Northwest National Laboratory; see also AREST-CT
AREST-CT working version 1995	Coupled reactive chemical transport, radionuclide release, and effects of near-field chemistry on radionuclide transport	Engineered barrier system performance analysis in support of total system performance assessments	In development; development aspects (Engel et al., 1994; 1995, in prep.); maintained by CRWMS M&O; see also AREST
A-TOUGH Vs. N/A 1993	Version of V-TOUGH with atmospheric interaction	Simulation of moisture removal from the repository by ventilation	User's manual (Multimedia, 1993); maintained by Multimedia Environmental Technology, Inc.; see also ITOUGH2, TOUGH/TOUGH2, and V-TOUGH

Table I-1. Analytical Techniques (continued)

Name	Process	YMP Applications	Status
BEALEP* Vs. 1.6 1994	Computes measure of saturated ground-water flow model linearity using output from MODFLOWP	Regional and site-scale saturated ground-water flow analysis in support of site characterization	Documentation (Hill, 1994); maintained by U.S. Geological Survey; see also MODFLOWP
CLIMATE working version 1996	Heat and mass transport within underground excavations, including water vapor and air ventilation	Analysis of ESF and repository drift ventilation	Development aspects (Danko et al., 1995, 1996)
CLIMSIM Vs. 2.0 1986	Climatic conditions in underground working areas considering heat sources, age, and wetness of airways	Analysis of climatic working conditions in ESF and repository drifts	User's manual (Mine Ventilation Services, 1986); maintained by Mine Ventilation Services, Inc.
COYOTE Vs. II 1994	Multi-dimensional nonlinear heat conduction and related general diffusion processes in solids	Analyses of rock temperatures surrounding the potential repository	Documentation (Gartling, 1982; Gartling and Hogan, 1994); maintained at Sandia National Laboratories
DIPS* Vs. 3.1* Jan 95 Vs. 4.0 1996	Plotting, analysis, and presentation of geologic structure using spherical projection techniques	Analysis of ESF fracture data (input to UNWEDGE)	User's manual (Diederichs and Hoek, 1996), vs. 3.1 qualification (CRWMS M&O, 1995i); maintained at University of Toronto
DORT-2D TORT-3D Vs. 2.12.14 Jan 95	Two- and three-dimensional discrete ordinates neutron and photon transport	Calculations of radiation doses in vicinity of waste packages	User's manual (ORNL, 1995a); maintained at Oak Ridge National Laboratory
Earthvision* Vs. 3.0 1995 Vs. 3.1* Nov 96	Three-dimensional geologic modeling	Basis of geologic framework model for Yucca Mountain	Vs. 3.0 user's manual (Dynamic Graphics, 1995), vs. 3.1 user's manual (CRWMS M&O, 1996mm), vs. 3.1 qualification (Clayton, 1996); maintained by Dynamic Graphics, Inc.
ELFPOINT working version 1992	Rock deformation resulting from shear and tensile faulting	Support of seismic ground-water pumping analysis to compute seismically induced elastic rock deformations	Theory (Okada, 1992)

Table I-1. Analytical Techniques (continued)

Name	Process	YMP Applications	Status
EQ3/6* Vs. 7.2a* Aug 94 Vs. 7.2b Aug 95	Speciation and solubility in aqueous solutions and geochemical reaction path/mass transfer	Analyses of ground-water chemistry data, calculations of solubility limits, and determination if certain reactions are in equilibrium or disequilibrium states	Theory and user's manual (Daveler and Wolery, 1992; Wolery, 1992a and b; Wolery and Daveler, 1992); maintained at Lawrence Livermore National Laboratory
FEHM Vs. 1.0 1988	Multi-dimensional multiphase flow and transport of water, water vapor, non-condensable gases, dissolved solids, and heat in porous and fractured media; finite element method	Thermal-hydrologic and mass transport modeling of unsaturated and saturated zone; ground-water travel time calculations	Theory (Zyvoloski et al., 1988); verification (Zyvoloski and Dash, 1991); maintained at Los Alamos National Laboratory; see also FEHMN
FEHMN* Vs. 96-05-07-sun4 May 96	Multi-dimensional multiphase flow and transport of water, water vapor, non-condensable gases, dissolved solids, radionuclides, and heat in porous and fractured media; finite element method	Thermal-hydrologic and radionuclide transport modeling of unsaturated and saturated zone; ground-water travel time calculations	Theory (Zyvoloski et al., 1996), user's manual (Zyvoloski et al., 1997), verification and validation (Dash et al., 1996); maintained at Los Alamos National Laboratory; see also FEHM
FLAC* Vs. 3.22* Jun 93	Two-dimensional plastic deformation of soil, rock or other solid-material structures; finite difference method	Geomechanical analyses of ESF subsurface design and ESF tests	User's manual (Itasca, 1993a), qualification (CRWMS M&O, 1993e); maintained by Itasca Consulting Group, Inc.; see also FLAC3D
FLAC3D* Vs. 1.01* Jan 95	Three-dimensional plastic deformation of soil, rock or other solid-material structures; finite difference method	Geomechanical analyses of ESF subsurface design, including portal and opening stability	User's manual (Itasca, 1994b), vs. 1.01 qualification (CRWMS M&O, 1995j); maintained by Itasca Consulting Group, Inc.; see also FLAC
FRACMAN* Vs. 2.511	Data analysis (FracSys), geometric simulation and analysis (FracWorks), and stochastic continuum field generation (EdMesh) for three-dimensional discrete fracture networks	Simulation of geometry and hydrogeologic characteristics of fracture networks in Yucca Mountain hydrogeologic units (input to MAFIC)	User documentation (Dershowitz et al., 1995a,b; Lee et al., 1995), verification (Busse, 1995 a,b); maintained by Golder Associates, Inc.; see also MAFIC
GCM	Global climate modeling	Input to regional and local climate modeling	Maintained by National Center for Atmospheric Research

Table I-1. Analytical Techniques (continued)

Name	Process	YMP Applications	Status
GENESIS* Vs. 2.01 1995	Global climate modeling	Provides regional boundary conditions for regional climate modeling by RegCM2	User's manual (Pollard and Thompson, 1995), validation (Thompson et al., in prep.); maintained by National Center for Atmospheric Research
GENII Vs. N/A Dec 90 GENII-S Vs. 1.485 1993	Biosphere radionuclide transport and radiation doses to humans by direct exposure, ingestion, and inhalation	Pre- and postclosure radiological exposure and risk calculations	Theory (Napier and Peloquin, 1988); user's manual (SNL, 1993); maintained at Pacific Northwest National Laboratory
GIMRT - see OS3D/GIMRT			
GWRAND working version 1996	Two-dimensional unsaturated ground-water particle tracking, random walk dispersion; semi-analytical method	Unsaturated zone ground-water travel time analyses	Theory (Lu, 1994), preliminary documentation (Altman et al., 1996a); maintained at Sandia National Laboratories
ITOUGH2* Vs. 2.2 Oct 96 Vs. 3.0 Dec 96	Calculation of TOUGH2 parameter values by automatic calibration with measured data; inverse analysis technique	Design and analysis of field and laboratory experiments	User's manual (Finsterle, 1993), vs. 2.2 qualification (Finsterle et al., 1996); maintained at Lawrence Berkeley National Laboratory; see also A-TOUGH, TOUGH/TOUGH2, and V-TOUGH
JAC JAC2D* Vs. N/A 1993	Large deformation, temperature-dependent, quasi-static mechanics problems in two dimensions	Thermal-mechanical behavior of rock mass for north ramp design 2C package; also for setup of ESF thermal-mechanical tests	User's manual (Biffle, 1981); maintained at Sandia National Laboratories; see also JAC3D
JAC3D* Vs. N/A 1993	Large deformation, temperature-dependent, quasi-static mechanics problems in three dimensions	Thermal-mechanical behavior of rock mass for north ramp design 2C package; also for ESF single-heater test as-built predictions	User's manual (Biffle, 1993); maintained at Sandia National Laboratories; see also JAC and JAC2D
LYNX System* Vs. 1.0* May 94 Vs. 1.1* Oct 94 Vs. 3.06* Jan 95 Vs. 3.10 1996 Vs. 4.4 Sep 96	Three-dimensional modeling of geologic features and mine design	Geology and underground design modeling support of ESF and repository development and design	User's manual (Lynx, 1994, 1996), vs. 1.0 qualification (CRWMS M&O, 1994d), vs. 1.1 qualification (CRWMS M&O, 1994e), vs. 3.06 qualification (CRWMS M&O, 1995c); maintained by Lynx Geosystems, Inc.

Table I-1. Analytical Techniques (continued)

Name	Process	YMP Applications	Status
MACCS Vs. 1.5.11.1 Oct 93	Radiation doses to humans	Calculations of radiation doses to workers and the general public	Theory (Jow et al., 1990), user's manual (Chanin et al., 1990), programmer's manual (Rollstin et al., 1990), maintenance release (Chanin et al., 1993); maintained by U.S. Nuclear Regulatory Commission
MAFIC* Vs. 1.53 1995	Three-dimensional isothermal fluid flow and particle transport in discrete fracture networks with matrix interaction; finite-element method	Analysis of discrete fracture flow and mass transport in Yucca Mountain hydrogeologic units	User documentation (Miller et al., 1995), verification (Busse, 1995c); maintained by Golder Associates, Inc.; see also FRACMAN
MCNP* Vs. 4.2* Vs. 4A* Mar 94 May 96	Three-dimensional criticality and shielding analysis for nuclear/radioactive systems; Monte Carlo technique	Criticality and shielding analyses in support of waste package, surface facility, and repository development and design	Theory (Briesmeister, 1993, 1995), primer (Harmon et al., 1994), vs. 4.2 qualification (CRWMS M&O, 1994f), vs. 4A qualification (CRWMS M&O, 1996nn); maintained at Los Alamos National Laboratory
MLAEM Vs. 4.0 1995	Two-dimensional and quasi-three-dimensional saturated ground-water flow; analytical element method	Regional saturated ground-water flow analysis to establish boundary conditions for site-scale saturated zone modeling in support of site characterization	Basic theory (Strack, 1989; Haitjema, 1995), user's manual (Strack, 1992a); maintained by Strack Engineering; see also SLAEM
MODFLOW Vs. 1638 1988	Two- and quasi-three-dimensional saturated ground-water flow; finite difference method	Regional and site-scale saturated ground-water flow analysis in support of site characterization	Documentation (McDonald and Harbaugh, 1988); maintained by U.S. Geological Survey; see also MODPATH
MODFLOWP Vs. 2.3 1992	Two- and quasi-three-dimensional saturated ground-water flow; finite difference method; parameter estimation using non-linear regression	Regional and site-scale saturated ground-water flow analysis in support of site characterization	Documentation (Hill, 1992); maintained by U.S. Geological Survey; see also BEALEP, MODPATH, RESANP, and YCINT
MODPATH MODPATH- PV 1994	Calculates position and travel time of particles for saturated ground-water flow, using output from MODFLOW or MODFLOWP	Regional ground-water flow analysis in support of site characterization	Documentation (Pollock, 1994); maintained by U.S. Geological Survey; see also MODFLOW and MODFLOWP

Table I-1. Analytical Techniques (continued)

Name	Process	YMP Applications	Status
MPSalsa working version in preparation	Two-dimensional two-phase (gas/liquid) flow in heterogeneous porous media; finite element method	Thermal-hydrological modeling of unsaturated zone air and water flow	Theory (Shadid and Moffat, in prep.); user's manual (Shadid et al., in prep.); maintained at Sandia National Laboratories
NETPATH* Vs. 2.0 1994	Geochemical mass balance	Hydrochemical characterization of unsaturated zone; correction of carbon-14 age dates of perched water	Documentation (Plummer et al., 1994)
NUFT Vs. 1.0 1995	Three-dimensional multiphase flow and transport of water, water vapor, gas, dissolved solids, radionuclides, and heat; integrated finite difference method	Thermal-hydrologic modeling of unsaturated and saturated zone in support of site characterization, engineered barrier system design studies, and performance assessments	Reference manual (Nitao, 1995); maintained at Lawrence Livermore National Laboratory
ORIGEN ORIGEN2 Vs. 2.1 1980	Build-up and decay of radioisotopes in nuclear fission reactor and in spent fuel after removal from reactor, including associated heat generation	Generation of list, weight, and radioactivity of radionuclides and of heat generated in support of MGDS development and design and performance assessments	Theory (Bell, 1973), user's manual (Croff, 1980); maintained at Oak Ridge National Laboratory
OS3D/GIMRT Vs. 1.0 Dec 95	Multi-dimensional multicomponent reactive mass transport	Reactive mass transport modeling (water chemistry, porosity/permeability, and mineralogy) of the altered zone and repository near field	User's and programmer's manual (Steeffel and Yabusaki, 1995); maintained at University of South Florida, modified at Lawrence Livermore National Laboratory
PATH Vs. 88A 1988	Gamma shielding analysis for three-dimensional source-shield configuration; point-kernel integration technique	Calculation of gamma dose rates from waste packages and support of MGDS shielding development and design	Theory and user's manual (Su et al., 1987), validation (Boshoven, 1991); qualification (Su, in prep.); maintained by General Atomics
PEST* Vs. 2.01 1994	Parameter-estimation for saturated ground-water flow models	Site-scale saturated ground-water flow analysis in support of site characterization	User's manual (Watermark Computing, 1994); maintained by Watermark Computing
PIGS working version in preparation	Pitting corrosion of waste package containers	Interpretation of pitting corrosion experiments, potential component of waste package and total system performance assessment models	Theory (Henshall, in prep.); being developed at Lawrence Livermore National Laboratory

Table I-1. Analytical Techniques (continued)

Name	Process	YMP Applications	Status
RegCM2* Vs. N/A 1995	Regional climate model	Provides boundary conditions for modeling future net infiltration at Yucca Mountain	Validation (Thompson et al., 1995); component of GENESIS; maintained by National Center for Atmospheric Research
RESANP* Vs. 1.3 1994	Calculates linear confidence intervals on estimated saturated ground-water flow parameters output from MODFLOWP	Regional and site-scale saturated ground-water flow analysis in support of site characterization	Documentation (Cooley and Naff, 1990; Hill, 1994); maintained by U.S. Geological Survey; see also MODFLOWP
RIP Vs. 4.05 1996	Total system postclosure performance assessment for radionuclide releases to accessible environment and radiation doses to the public	Total system postclosure performance assessments	Theory and user's manual (Golder, 1996), verification (Golder, 1995); maintained by Golder Associates, Inc.
SATTRAK working version 1996	Three-dimensional saturated ground-water particle tracking, random walk dispersion; finite element method	Saturated zone ground-water travel time analyses	Development aspects (Altman et al., 1996a); maintained at Sandia National Laboratories
SCALE System* Vs. 4.2* Jan 96 Vs. 4.3* Dec 96	Criticality safety, shielding, heat transfer, and nuclear decay/fuel depletion analysis for nuclear facilities and waste package designs	Criticality, shielding, source term, and decay heat analysis in support of waste package development and design	Theory and user's manual (NRC, 1993; ORNL, 1995b), vs. 4.2 qualification (CRWMS M&O, 1996oo), vs. 4.3 qualification (CRWMS M&O, 1996pp); maintained at Oak Ridge National Laboratory
SLAEM Vs. 3.0 1995	Two-dimensional single-layer saturated ground-water flow; analytical element method	Regional saturated ground-water flow analysis to establish boundary conditions for site-scale saturated zone modeling in support of site characterization	Basic theory (Strack, 1989; Haitjema, 1995), user's manual (Strack, 1992b); maintained by Strack Engineering; see also MLAEM
STAADIII/ ISDS* Vs. 4-8MB, Rev. 16.0* Jun 93	Structural analysis and design, including columns, beams, and bracings for plane/space frame structures	Structural engineering analysis and design applications for plane trusses, plane frames, and space frames in the ESF	User's manual (Research Engineers, 1992), qualification (CRWMS M&O, 1993f); maintained by Research Engineers, Inc.
3D 1992	Multi-dimensional isothermal flow and radionuclide transport in anisotropic saturated porous and fractured media; finite element method	Hydrothermal analyses in support of site characterization	Theory (Huyakorn et al., 1992); maintained by HydroGeoLogic, Inc.

Table I-1. Analytical Techniques (continued)

Name	Process	YMP Applications	Status
TOSPAC Vs. 1.10 1992	Radionuclide release from waste packages and one-dimensional, unsaturated isothermal water flow and radionuclide transport in fractured media; finite-difference method	Input to total system postclosure performance assessments	Theory (Dudley et al., 1988), user's manual (Gauthier et al., 1992); maintained at Sandia National Laboratories
TOUGH TOUGH2* Vs. 1.11* Feb 96	Multi-dimensional multiphase flow and transport of water, water vapor, non-condensable gases, dissolved solids, radionuclides, and heat in porous and fractured media; integrated finite difference method	Thermal-hydrological modeling of unsaturated and saturated zone; ground-water travel time calculations; design of laboratory and in-situ thermohydrologic experiments	Theory and user's guide (Pruess, 1987; Pruess et al., 1991), conjugate gradient solvers (Moridis and Pruess, 1995), TOUGH2 vs. 1.11 qualification (Pruess et al., 1996), qualification of TOUGH2 modules (Wu et al., 1996); maintained at Lawrence Berkeley National Laboratory; see also A-TOUGH, ITOUGH2, and V-TOUGH
TRACRN TRACR3D Vs. N/A 1991	Multi-dimensional isothermal liquid and gas flow and multi-component tracer/radionuclide transport in porous and fractured media; finite difference method	Radionuclide transport modeling in support of site characterization; design of laboratory and in situ tracer experiments	Theory and user's manual (Travis, 1984; Travis and Birdsell, 1988; Birdsell and Travis, 1991); maintained at Los Alamos National Laboratory
TSA working version 1994	Collection of programs for total-system postclosure performance assessment for radionuclide releases to accessible environment	Total system postclosure performance assessments	Development aspects (Barnard et al., 1992; Wilson et al., 1994); maintained at Sandia National Laboratories
UDEC* Vs. 2.0* Mar 94	Two-dimensional response of discontinuous media (such as jointed rock mass) represented as an assemblage of discrete blocks; distinct element method	Analysis of underground openings (in jointed medium) subjected to in situ and seismic loadings in support of ESF and repository development and design	User's manual (Itasca, 1993b), vs. 2.0 qualification (CRWMS M&O, 1994g); maintained by Itasca Consulting Group, Inc.
UNWEDGE* Vs. 2.2* Jan 95	Three-dimensional analysis of geometry and stability of wedges defined by intersecting structural discontinuities in underground excavations, including rock bolts and shotcrete	ESF and repository excavation stability analyses	User's manual (Carvalho et al., 1992), vs. 2.2 qualification (CRWMS M&O, 1995k); maintained at University of Toronto

Table I-1. Analytical Techniques (continued)

Name	Process	YMP Applications	Status
VNETPC* Vs. 3.1* Oct 93	Analysis of subsurface facility ventilation for mine networks, considering gaseous emissions, and design and cost analysis of ventilation equipment	Analysis and design of ESF and repository ventilation systems, including dust and diesel locomotive hydrocarbon exhausts	User's manual (Mine Ventilation Services, 1993), qualification (CRMWS M&O, 1993g); maintained by Mine Ventilation Services, Inc.
V-TOUGH* Vs. 7.8* Sep 95	Vectorized multi-dimensional multiphase flow and transport of water, water vapor, and heat in porous and fractured media; integrated finite difference method	Thermal-hydrologic modeling of unsaturated and saturated zone in support of thermal loading and engineered barrier system development and design	Theory and user's manual (Nitao, 1990); maintained at Lawrence Livermore National Laboratory; see also A-TOUGH, ITOUGH2, and TOUGH/TOUGH2
WAPDEG Vs. 1.0 Sep 96	Waste package degradation	Input to total system postclosure performance assessments	User's manual (Atkins and Lee, 1996)
WEEPTSA working version 1994	Probabilistic analysis of interaction of water flowing in discrete fractures with waste containers, radionuclide release, and transport to the water table	Input to total system postclosure performance assessments	In development; documentation (Barnard et al., 1992; Wilson et al., 1994); maintained at Sandia National Laboratories
X1t working version	One-dimensional multicomponent reactive mass transport	Reactive mass transport modeling (water chemistry, porosity/permeability, and mineralogy) of the altered zone and repository near field	Unpublished; obtained by Lawrence Livermore National Laboratory at 1996 University of Illinois short course "Reactive Transport and Basin Modeling"
YCINT Vs. 1.2 1994	Calculates linear confidence intervals on estimated saturated ground-water flow parameters output from MODFLOWP	Regional and site-scale saturated ground-water flow analysis in support of site characterization	Documentation (Hill, 1994); maintained by U.S. Geological Survey; see also MODFLOWP
YMIM Vs. 2.1 Apr 95	Radionuclide release from waste form and waste packages	Input to total system postclosure performance assessments; development and design of waste form and waste package experiments	User's manual (Gansemer and Lamont, 1995); maintained at Lawrence Livermore National Laboratories

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Abbreviations and acronyms:

CD-ROM = compact disc - read-only memory
 CR^{WMS} M&O = Civilian Radioactive Waste Management System
 Management and Operating Contractor
 ESF = Exploratory Studies Facility
 MGDS = mined geologic disposal system

N/A = not applicable or not available
 SNL = Sandia National Laboratories
 Vs. = version
 YMP = Yucca Mountain Site Characterization Project

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Table I-2. Cross-Reference between Modeling Descriptions and Progress Report Sections

Names added since Progress Report #15 are in bold type. No computer codes were deleted.

Name	Description	Development and Improvement	Testing and Verification	Model Validation	Application
3DEC	Excavation rock mechanics				
ABAQUS	Soil and rock mechanics				5.2.4
ANSYS	Thermal-mechanics		5.1.2		5.1.3 5.2.3
AREST AREST-CT	Waste package degradation and radionuclide release				
A-TOUGH	V-TOUGH with atmospheric interaction				
BEALEP	Measure of MODFLOWP model linearity				
CLIMATE	Drift ventilation analysis and design				
CLIMSIM	Drift climatic conditions				
COYOTE	Heat conduction and diffusion in solids				
DIPS	Geologic structure analysis and graphics				
DORT-2D TORT-3D	Neutron and photon transport		5.1.2		
Earthvision	Geologic modeling				
ELFPOINT	Rock deformation from shear and tensile faulting				
EQ3/6	Geochemical speciation, solubility, and reactions		3.2.4	5.2.2	5.2.2 6.10.5
FEHM FEHMN	Multiphase fluid and heat flow with radionuclide transport	3.2.14			3.1.6 3.1.16 3.2.2 3.2.5
FLAC FLAC 3D	Soil and rock mechanics				5.2.4
FRACMAN	Fracture network geometry and parameter analysis				5.2.4
GCM	Global climate modeling				3.1.4 3.1.5

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Table I-2. Cross-Reference between Modeling Descriptions and Progress Report Sections (continued)

Name	Description	Development and Improvement	Testing and Verification	Model Validation	Application
GENESIS	Global climate modeling				
GENII GENII-S	Biosphere radionuclide transport and radiation doses				
GIMRT - see OS3D/GIMRT					
GWRAND	Unsaturated zone ground-water particle tracking				
ITOUGH2	Calculation of TOUGH2 parameter values				3.1.13
JAC JAC2D JAC3D	Large deformation mechanics				
LYNX	Modeling of geology and under-ground facility design				4.1.3 4.1.7
MACCS	Radiation doses to humans				
MAFIC	Fluid flow in discrete fracture networks				5.2.4
MCNP	Criticality and shielding		5.1.2		
MLAEM	Saturated ground-water flow				
MODFLOW	Saturated ground-water flow				
MODFLOWP	Saturated ground-water flow				3.1.4
MODPATH MODPATH- PLOT	Saturated ground-water particle transport				
MPSalsa	Two-phase fluid and heat flow				
NETPATH	Geochemical mass balance				3.1.11
NUFT	Multiphase fluid and heat flow with radionuclide transport		3.14		3.1.4 5.2.3
ORIGEN ORIGEN2	Nuclear fuel decay and heat generation				
OS3D/GIMRT	Multicomponent reactive mass transport		3.14		3.14 6.10.5 6.10.12

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Table I-2. Cross-Reference between Modeling Descriptions and Progress Report Sections (continued)

Name	Description	Development and Improvement	Testing and Verification	Model Validation	Application
PATH	Gamma shielding analysis				
PEST	Saturated ground-water flow model parameter estimation				3.1.16
PIGS	Pitting corrosion	6.9.9			
RegCM2	Regional climate model				
RESANP	Linear confidence intervals for MODFLOWP output				
RIP	Total system postclosure performance			6.10.12	
SATTRAK	Saturated zone ground-water particle tracking				
SCALE	Criticality, shielding, heat transfer, nuclear decay		5.1.2 5.1.3		
SLAEM	Saturated ground-water flow				
STAADIII/ ISDS	Structural analysis of columns, beams, frames				
STAFF3D	Saturated ground-water flow and radionuclide transport				
TOSPAC	Unsaturated zone flow, waste package radionuclide release, and radionuclide transport				
TOUGH TOUGH2	Multiphase fluid and heat flow with radionuclide transport	3.1.13	3.1.13		3.1.13 3.2.2
TRACRN TRACR3D	Liquid and gas flow with radionuclide transport				
TSA	Total system postclosure performance				
UDEC	Jointed-rock mechanics				
UNWEDGE	Jointed-rock mechanics				
VNETPC	Ventilation of underground excavations				
V-TOUGH	Multiphase fluid and heat flow				

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Table I-2. Cross-Reference between Modeling Descriptions and Progress Report Sections (continued)

Name	Description	Development and Improvement	Testing and Verification	Model Validation	Application
WAPDEG	Waste package barrier degradation and corrosion				
WEEPSTA	Probabilistic discrete fracture ground-water flow				
X1t	Multicomponent reactive mass transport				6.10.12
YCINT	Linear confidence intervals for MODFLOWP output				
YMIM	Waste package radionuclide release				

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APPENDIX J

Glossary

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APPENDIX J

Glossary

Accessible environment means the atmosphere, the land surface, surface water, oceans, and the portion of the lithosphere that is outside the controlled area.

Advanced conceptual design (ACD) means the design phase that will be used to explore selected design alternatives and will firmly fix and refine the design criteria and concepts to be made final in later design efforts. The project feasibility will be demonstrated, life-cycle costs estimated, preliminary drawings prepared, and a construction schedule developed as required by U.S. Department of Energy Order 6410.1.

Advection means transport that results from macroscopic fluid flow.

Aquifer means a formation, a group of formations, or a part of a formation that contains sufficient saturated permeable material to yield sufficient quantities of water to wells and springs.

Areal mass loading means the amount of heavy metal (usually expressed in metric tons of uranium or equivalent) emplaced per unit area in the proposed repository.

Backfill means (1) The general fill that is placed in the excavated areas of the underground facility. Backfill materials may be either excavated tuff or other earthen materials. (2) The material or process used to refill an excavation.

Barrier means any material or structure that prevents or substantially delays the movement of water or radionuclides.

Borehole means a hole made with a drill, auger, or other tools for exploring strata in search of minerals, supplying water for blasting, emplacing waste, proving the position of old workings or faults, or releasing accumulations of gas or water. Boreholes include core holes, dry-well-monitoring holes, waste-emplacment boreholes, and test holes for geophysical or ground-water characterization.

Bulk permeability means volume-averaged permeability. See "permeability."

Burnup means a measure of nuclear-reactor fuel consumption expressed either as the percentage of fuel atoms that have undergone fission or as the amount of energy produced per unit weight of fuel.

Canister is a metal receptacle with the following purpose: (1) for solidified high-level radioactive waste, its purpose is a pour mold, and (2) for spent fuel, it may provide structural support for loose rods, nonfuel components, or confinement of radionuclides during preclosure operations.

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Cladding means the metallic outer sheath of a fuel element, generally made of stainless steel or a zirconium alloy.

Closure means final backfilling of the remaining open operational areas of the underground facility after the termination of waste emplacement, culminating in the sealing of shafts.

Confinement as it pertains to radioactivity, means the retention of radioactive material within some specified bounds. Confinement differs from containment in that there is no absolute physical barrier in the former.

Contact (geology) means a plane or irregular surface between two different types or ages of rocks.

Containment means the confinement of radioactive waste within a designated boundary.

Controlled area means a surface location, to be marked by suitable monuments, extending horizontally no more than 10 kilometers in any direction from the outer boundary of the underground facility, and the underlying subsurface, which area has been committed to use as a geologic repository and from which incompatible activities would be prohibited before and after permanent closure.

Core science means those disciplines capable of providing information and data needed to address the major unresolved technical questions regarding the conceptual design of the repository and/or its expected performance in the geologic setting.

Criticality means the condition of supporting a nuclear chain reaction. It occurs when the number of neutrons present in one generation cycle equals the number generated in the previous cycle.

Defense high-level nuclear waste means the high-level waste generated in the course of national defense activities.

Diffusion means transport that results from random thermal motion of molecules.

Dispersion means the solute-spreading or dilution phenomena caused by mechanical mixing during ground-water movement and molecular diffusion.

Disposal means the emplacement in a repository of high-level radioactive waste, spent nuclear fuel, or other highly radioactive material with no foreseeable intent of recovery, whether or not such emplacement permits the recovery of such waste, and the isolation of such waste from the accessible environment.

Disposal container is a vessel consisting of the barrier materials and internal components designed to meet disposal requirements, into which the uncanistered or canistered waste form will be placed.

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Drawdown means the lowering of the water table or potentiometric surface caused by pumping.

Drift means a horizontal or nearly horizontal, mined passageway.

Emplacement means the act of placing waste containers in prepared positions.

Engineered barrier system means the waste packages and the underground facility.

Environmental impact statement means the document required by Section 102(2)(C) of the National Environmental Policy Act of 1969. Sections 114(a) and 114(f) of the Nuclear Waste Policy Act of 1982 include certain limitations on the National Environmental Policy Act requirements as they apply to the preparation of an environmental impact statement for the development of a repository at a characterized site.

Exploratory studies facility means a facility constructed for the purpose of performing underground studies during site characterization.

Fault means a fracture or a zone of fractures along which there has been displacement of the sides relative to one another parallel to the fracture or zone of fractures.

Finite-element computer code means a computer code that uses the finite-element method. The finite-element method is a method of numerical analysis that divides a region of interest into discrete elements and represents the behavior of the elements with a set of simultaneous equations. Solution of the set of equations yields the behavior at discrete points within the region of interest.

Flow path means the theoretical line that ground water follows in moving from a recharge area to a discharge area.

Flux means the volume of fluid per unit area per unit time. Also known as specific discharge.

Fracture is a general term for any break in a rock, whether or not it causes displacement, due to mechanical failure by stress. Fractures include cracks, joints, and faults.

Geochemistry means the study of the distribution and amounts of the chemical elements in minerals, ores, rocks, soils, water, and the atmosphere and the chemical interactions between these phases.

Geologic repository means a system, requiring licensing by the U.S. Nuclear Regulatory Commission, that is intended to be used, or may be used, for the permanent disposal of radioactive waste (including spent nuclear fuel) in excavated geologic media. A geologic repository includes (1) the geologic repository operations area and (2) the portion of the geologic setting that provides isolation of the radioactive waste and is located within the controlled area.

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Geomechanics means the branch of geology that deals with the response of earth materials to deformational forces and embraces the fundamentals of structural geology.

Ground-water flux means the rate of ground-water flow per unit area of porous or fractured media measured perpendicular to the direction of flow.

Ground-water travel time means the time required for a unit volume of ground water to travel between two locations. The travel time is the length of the flow path divided by the velocity, where velocity is the average ground-water flux passing through the cross-sectional area of the geologic medium through which flow occurs, perpendicular to the flow direction, divided by the effective porosity along the flow path. If discrete segments of the flow path have different hydrologic properties, the total travel time will be the sum of the travel times for each discrete segment.

Guidelines means Part 960 of Title 10 of the Code of Federal Regulations—General Guidelines for the Recommendation of Sites for Nuclear Waste Repositories.

High-level radioactive waste means (1) the highly radioactive material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and (2) other highly radioactive material that the U.S. Nuclear Regulatory Commission, consistent with existing law, determines by rule requires permanent isolation.

Hundred-year storm means a storm whose intensity is such, on a statistical basis, that it is expected to recur only once every 100 years.

Hydrogeologic properties means the properties of a rock that govern the entrance of water and the capacity to hold, transmit, and deliver water, such as porosity, effective porosity, specific retention, permeability, and the directions of maximum and minimum permeabilities.

Hydrologic unit means any soil or rock unit or subsurface zone that affects the storage or movement of ground water by its porosity or permeability.

In situ means in its natural or original position. The phrase distinguishes in-place experiments, conducted in an underground facility from those conducted in the laboratory.

Infiltration means the flow of a fluid into a substance through pores or small openings. It connotes flow into a substance as opposed to the word percolation, which connotes flow through a substance.

Invert has two meanings on the Project. Its general meaning is the low point of something such as a tunnel, drift or drainage channel. However, as mostly used herein, invert means an engineered structure or material placed on excavated drift floors (the low points) to serve as structural support for drift transportation or emplacement systems. (For precast concrete, the proper name is invert segments, but they are commonly referred to simply as inverts.) Typical

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invert (segments) convert rounded excavated floors to flat level surfaces for transportation system use. Emplacement drift inverts may be specially designed to enhance the waste isolation and criticality prevention capabilities of the proposed repository through choice of invert materials or invert shape. Inverts may also be used to help channel water to improve repository drainage.

Issue means a question relating to the performance of the mined geologic disposal system that must be resolved to demonstrate compliance with the applicable Federal regulations (including 10 CFR Part 60, 10 CFR Part 960, applicable Environmental Protection Agency standards, and 10 CFR Part 20).

Isolation means inhibiting the transport of radioactive material so that the amounts and concentrations of this material entering the accessible environment will be kept within prescribed limits.

License application means an application for a license from the U.S. Nuclear Regulatory Commission to construct a repository.

Lithophysae means voids in rocks composed of concentric shells of finely crystalline alkali feldspar, quartz, and other materials that were formed due to entrapped gas that later escaped.

Maximally exposed individual means a hypothetical person who is exposed to a release of radioactivity in such a way that he receives the maximum possible individual radiation dose or dose commitment. For instance, if the release is a puff of contaminated air, the maximally exposed individual is a person at the point of the largest ground-level concentration and stays there during the whole time the contaminated-air cloud remains above. This term is not meant to imply that there really is such a person; it is used only to indicate the maximum exposure a person could receive.

Metric tons heavy metal means metals with high atomic numbers which are loaded into nuclear reactors to take part in chain reactions. Examples of heavy metals include thorium, uranium, plutonium, and neptunium. When used in the Civilian Radioactive Waste Management Program, the term usually refers to the mass of heavy metal in spent fuel which was present when the fuel was initially loaded into a reactor. (A metric ton is a unit of mass equal to 1000 kg.)

Mined geologic disposal system means a system, requiring licensing by the U.S. Nuclear Regulatory Commission, that is used for the disposal of high-level radioactive waste in excavated geologic media. It is synonymous with "geologic repository."

Multibarrier system means a system of natural and engineered barriers, operating independently or relatively independently, that acts to contain and isolate the waste.

Multi-purpose canister means a sealed, metallic canister holding multiple spent nuclear fuel assemblies in a dry, inert environment and overpacked separately and uniquely for the various system elements of storage, transportation, and disposal.

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National Environmental Policy Act means the Federal statute that is the national charter for protection of the environment. The Act is implemented by procedures issued by the Council on Environmental Quality and the DOE. The National Environmental Policy Act of 1969 appears at 42 U.S.C. 4321 et seq.

Natural barrier means the physical, mechanical, chemical, and hydrologic characteristics of the geologic environment that individually and collectively act to minimize or preclude radionuclide transport.

Natural system means a host rock suitable for repository construction and waste emplacement and the surrounding rock formations. It includes natural barriers that provide containment and isolation by limiting radionuclide transport through the geohydrologic environment to the biosphere and provide conditions that will minimize the potential for human interference in the future.

Near field means the region where the natural geohydrologic system has been significantly perturbed by the excavation of the repository and the emplacement of the waste.

Net infiltration means infiltration minus water lost to evapotranspiration and other processes such as circulation of air within the rock mass.

Notice of intent means a notice published in the Federal Register that an environmental impact statement will be prepared and considered by a Federal agency. The notice is required by the National Environmental Policy Act implementing procedures. The notice must describe the proposed action and possible alternatives; describe the agency's proposed scoping process including whether, when, and where any scoping meeting will be held; and state the name of an agency official who can answer questions about the proposed action and the environmental impact statement.

Nuclear Waste Policy Act (42 USC 10101 et seq.) means the Federal statute enacted in 1982 that established the Office of Civilian Radioactive Waste Management and defined its mission to develop a Federal system for the management and geologic disposal of commercial spent nuclear fuel and other high-level radioactive wastes, as appropriate. The Act also specified other Federal responsibilities for nuclear waste management, established the Nuclear Waste Fund to cover the cost of geologic disposal, authorized interim storage under certain circumstances, and defined interactions between Federal agencies and the states, local governments, and Indian tribes. The act was amended in 1987 and 1992.

Perched ground water means unconfined ground water separated from an underlying body of ground water by an unsaturated zone. Its water table is a perched water table. Perched ground water is held up by a perching bed whose permeability is so low that water percolating downward through it is not able to bring water in the underlying unsaturated zone above atmospheric pressure.

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Percolation means the passage of a liquid through a porous substance (e.g., the movement of water, under hydrostatic pressure developed naturally underground, through the interstices and pores of the rock or soils.)

Percolation flux means volume of water moving downward and/or laterally through the unsaturated zone in a given time period.

Performance assessment means any analysis that predicts the behavior of a system or system component under a given set of constant and/or transient conditions. Performance assessments will include estimates of the effects of uncertainties in data and modeling.

Performance confirmation means the program of tests, experiments, and analyses that is conducted to evaluate the accuracy and adequacy of the information used to determine with reasonable assurance that the performance objectives for the period after permanent closure can be met.

Permeability means the capacity of a medium like rock, sediment, or soil to transmit ground water. Permeability depends on the size and shape of the pores, joints, and fractures in the medium and the manner in which they are interconnected.

Postclosure means the period of time after the closure of the geologic repository.

Preclosure means the period of time before and during the closure of the geologic repository.

Primary area means the surface location, as indicated on a map, of the principal area that may be suitable for waste emplacement. When projected downward along the location of faults and other geologic features, the boundaries of the primary area encompass the principal region within the target emplacement horizon that is considered potentially suitable for waste emplacement.

Radioactive waste or "waste" means high-level radioactive waste and other radioactive materials, including spent nuclear fuel, that are received for emplacement in a geologic repository.

Repository construction means all excavation and mining activities associated with the construction of shafts, shaft stations, rooms, and necessary openings in the underground facility, preparatory to radioactive-waste emplacement, as well as the construction of necessary surface facilities, but excluding site-characterization activities.

Repository horizon means the horizontal plane within the host rock where the location of the proposed repository is planned.

Rock bolt means a bar, usually constructed of steel, that is anchored into predrilled holes in rock as a support device.

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Saturated zone means that part of the Earth's crust beneath the water table in which all voids, large and small, are ideally filled with water under pressure greater than atmospheric.

Seal means an engineered barrier to prevent radionuclide migration or the intrusion of undesirable substances.

Seepage means portion of percolation flux entering the emplacement drifts in a given time period.

Seismic means pertaining to, characteristic of, or produced by earthquakes or earth vibrations.

Shallow infiltration means water that has percolated to a depth of at least 2 meters into the bedrock closest to the surface. Two meters is usually assumed to be below the zone of substantial evapotranspiration.

Site means a potentially acceptable site or a candidate site, as appropriate, until such time as the controlled area has been established, at which time the site and the controlled area are the same.

Site characterization means activities, whether in the laboratory or in the field, undertaken to establish the geologic conditions and the ranges of the parameters of a candidate site relevant to the location of a repository, including borings, surface excavations, excavations of exploratory shafts, limited subsurface lateral excavations and borings, and in situ testing needed to evaluate the suitability of a candidate site for the location of a repository, but not including preliminary borings and geophysical testing needed to assess whether site characterization should be undertaken.

Sorption is a term including both adsorption and absorption, and means the binding, on a microscopic scale, of one substance to another, such as by adsorption or ion exchange. In this document, the word is especially used for the sorption of dissolved radionuclides onto aquifer solids or waste-package materials by means of close-range chemical or physical forces.

Spent nuclear fuel means fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing.

Stakeholders means individuals or organizations who have an important, ongoing interest in the service and service quality of the Office of Civilian Radioactive Waste Management.

Stoichiometry means (1) the application of the laws of definite proportions and of the conservation of matter and energy to chemical activity; (2) the quantitative relationship between constituents in a chemical reaction.

Storativity means the volume of water released from storage in a vertical column of unit area when the water table or other piezometric surface declines 1 unit of height. In an undefined aquifer, it is approximately equal to the specific yield.

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Stratigraphy is the branch of geology that deals with the definition and interpretation of the rock strata, the conditions of their formation, character, arrangement, sequence, age, distribution, and especially their correlation by the use of fossils and other means of identification.

Substantially complete containment means that containment of the radionuclides enclosed within the waste packages is substantially complete for 1000 years (with less than 1 percent of the waste packages failing within 1000 years after permanent closure of the geologic repository) and with a mean waste package lifetime well in excess of 1000 years.

Surface facilities means repository support facilities within the restricted area.

Systems engineering systemically applies science and engineering principles to control a complex total system development effort for the purpose of achieving an optimum balance of all system elements. It is a process that transforms and integrates operational needs and requirements into a description of system requirements to maintain the overall system effectiveness.

Thermal loading means the application of heat to a system, and is usually measured in terms of watt density. The thermal loading for a repository is the watts per acre produced by the radioactive waste in the active disposal area.

Thermogravimetric analysis means a method of analysis that measures the loss or gain of weight by a substance as the temperature of the substance is raised or lowered at a constant rate.

Tracer testing means a procedure in which a soluble substance (tracer) is added to ground water at one location and its movement to another location is observed. Tracer testing is a technique by which ground-water flow directions and velocities and other hydrologic properties of rocks can be estimated.

Transmissivity means the rate at which water of the prevailing kinematic viscosity is transmitted through a unit hydraulic gradient. It equals the hydraulic conductivity multiplied by the thickness of the aquifer.

Tuff means a rock formed of compacted volcanic ash and dust.

Unsaturated zone means the zone between the land surface and the water table. Generally, water in this zone is under less than atmospheric pressure, and some of the voids may contain air or other gases at atmospheric pressure. Beneath flooded areas or in perched water bodies, the water pressure locally may be greater than atmospheric.

Viability assessment means an Office of Civilian Radioactive Waste Management Program judgment about the prospects for geologic disposal at the Yucca Mountain site, based on repository and waste package designs, a total system performance assessment, a licensing completion plan, and repository cost and schedule estimates.

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Waste package means the waste form and any containers, shielding, packing, and other absorbent materials immediately surrounding an individual waste container.

10 CFR Part 60 means the Nuclear Regulatory Commission regulation, titled "Disposal of High-Level Radioactive Wastes in Geologic Repositories," that sets forth technical requirements governing development of a permanent geologic repository for spent nuclear fuel and high-level radioactive waste sited, constructed, and operated in accordance with the Nuclear Waste Policy Act of 1982.

10 CFR Part 960 means the Department of Energy regulation, titled "General Guidelines for the Recommendation of Sites for Nuclear Waste Repositories," that establishes guidelines for use by the Secretary of Energy in evaluating the suitability of sites for the development of nuclear waste repositories.

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APPENDIX K

Acronyms, Abbreviations, and Symbols

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APPENDIX K

ACRONYMS, ABBREVIATIONS, AND SYMBOLS

CRWMS	Civilian Radioactive Waste Management System
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ESF	Exploratory Studies Facility
FY	fiscal year
MGDS	Mined Geologic Disposal System
M&O	Civilian Radioactive Waste Management System Management and Operating Contractor
NRC	U.S. Nuclear Regulatory Commission
OCRWM	Office of Civilian Radioactive Waste Management
Program	Civilian Radioactive Waste Management Site Characterization Program
Project	Yucca Mountain Site Characterization Project
QA	quality assurance
SCP	Site Characterization Plan
USGS	U.S. Geological Survey
YMSCO	Yucca Mountain Site Characterization Office

Miscellaneous Terms, Units, and Designators

atm	atmosphere (pressure)
AISI	American Iron and Steel Institute
ASTM	American Society for Testing and Materials
ATM	approved testing material
darcy	a measure of the permeability of a porous medium; $1 \text{ darcy} = 9.87 \times 10^{-13} \text{m}^2$
Eh	oxidation potential, also called redox potential, of a chemical element, expressed in volts or millivolts
gpm	gallons per minute
ka	kiloannum (thousand years ago)
ky	thousand years
Ma	mega-annum (million years ago)
pH	the negative common logarithm of the hydrogen ion concentration of a solution; a measure of the acidity or alkalinity of the solution
pmc	percent modern carbon
ppb	parts per billion
ppm	parts per million
TU	tritium unit
UNS	Unified Numbering System for Metals and Alloys

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Borehole Letter Designators

c	Hydrologic test hole
G	Geologic
GA	Geologic Angle "exploratory hole"
GU	Geologic Unsaturated zone
h	Horizontal drilled hole
H	Hydrologic Research Facility holes
HPF	Hydrologic Properties of Faults
J	Jackass Flats (water wells)
N	Neutron hole
NRG	North Ramp Geologic hole
ONC	Oversight Nye County
p	Paleozoic or pre-Tertiary hole
RBT	Radial Borehole Tests
RF	Repository Surface Facility hole
SD	Systematic Drilling hole
SRG	South Ramp Geologic hole
UE	Underground Exploratory
USW	Underground Southern (Nevada) Waste hole
UZ	Unsaturated Zone hole
UZN	Unsaturated Zone Neutron hole
V	Volcanic hole
VH	Volcanic/Hydrologic hole
WT	Water Table hole

Hydrogeologic Unit Names

CFu	Crater Flat unit
CHn	Calico Hills nonwelded unit
PTn	Paintbrush nonwelded unit
TCw	Tiva Canyon welded unit
TSw	Topopah Spring welded unit

SI and Metric Units

°C	degree Celsius
cm ³	cubic centimeter
cm	centimeter (= 10 ⁻² m or 0.3937 inch)
d	day
g	gram (= 0.03527 ounce)
GWd	gigawatt-day
h	hour
ha	hectare (= 2.48 acres)

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Hz	hertz (cycles per second)
J	joule (newton-meter)
K	degree kelvin
kg	kilogram (= 10^3 grams or 2.2046 pounds)
kWh	kilowatt-hour
km	kilometer (= 10^3 m or 0.6214 mile)
L	liter (= 0.2642 gallon)
MTU	metric tons of uranium equivalent
MTIHM	metric tons of initial heavy metal
m	meter (= 3.2808 feet)
mg	milligram (= 10^{-3} g)
mgal	milligalileo
mL	milliliter (= 10^{-3} L)
mm	millimeter (= 10^{-3} m)
μ m	micrometer (= 10^{-6} m)
MWd	megawatt-day
MWh	megawatt-hour
nm	nanometer (= 10^{-9} m)
nT	nanotesla (= 10^{-9} tesla)
Pa	pascal (also, MPa = megapascal, kPa = kilopascal)
S	siemens
s	second
V	volt
W	watt

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APPENDIX L

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- 10 CFR Part 20 (Code of Federal Regulations), 1996. Title 10, "Energy," Part 20, "Standards for Protection Against Radiation," U.S. Government Printing Office, Washington, D.C.
- 10 CFR Part 60 (Code of Federal Regulations), 1997. Title 10, "Energy," Part 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories," U.S. Government Printing Office, Washington, D.C.
- 10 CFR Part 960 (Code of Federal Regulations), 1984. Title 10, "Energy," Part 960, "Nuclear Waste Policy Act of 1982; General Guidelines for the Recommendations of Sites for the Nuclear Waste Repositories," U.S. Government Printing Office, Washington, D.C.
- 40 CFR Part 191 (Code of Federal Regulations), 1993. Title 40, "Protection of Environment," Part 191, "Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes," U.S. Government Printing Office, Washington, D.C.
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- 61 FR 66157 (Federal Register), 12/16/95. "Notice of Proposed Rulemaking and Public Hearing, 10 CFR Part 960, General Guidelines for the Recommendation of Sites for Nuclear Waste Repositories," U.S. Government Printing Office, Washington, D. C.
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Note to Readers

To meet the requirements of Federal Executive Order 12906, the following information is provided:

"Map number YMP-96-152.3 was compiled on June 30, 1997 by the M&O/TRW Technical Data Management GIS Section. Source documentation for the data sets included in this map are available upon request."

"Map number YMP-96-153.1 was compiled on May 9, 1997 by the M&O/TRW Technical Data Management GIS Section. Source documentation for the data sets included in this map are available upon request."

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Accession No. HQ0•19970731•0001

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