rec'd w/ltr dtd 3/9/93

YMP/CM-0011

U.S. DEPARTMENT OF ENERGY

OCRWM

YUCCA MOUNTAIN

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

PROJECT BASELINE DOCUMENT

YUCCA MOUNTAIN SITE CHARACTERIZATION PROGRAM BASELINE (SCPB)

CHANGES TO THIS DOCUMENT REQUIRE PREPARATION AND APPROVAL OF A CHANGE REQUEST IN ACCORDANCE WITH PROJECT AP-3.3Q

UNITED STATES DEPARTMENT OF ENERGY
YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT OFFICE

102.8

U.S. DEPARTMENT OF ENERGY

OCRWM

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

Document No. YMP/CM-[illegible]
Revision 9
CI No. CI.11.0000/CI.13.[illegible]
Date 10/09/92
WBS No. 1.2.3
QA Level Yes

PROJECT BASELINE DOCUMENT

YUCCA MOUNTAIN SITE CHARACTERIZATION PROGRAM BASELINE (SCPB) VOLUME 1

CHANGES TO THIS DOCUMENT REQUIRE PREPARATION AND APPROVAL OF A CHANGE REQUEST IN ACCORDANCE WITH PROJECT AP-3.3Q

UNITED STATES DEPARTMENT OF ENERGY
YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT OFFICE

YMP-035-R0
4/22/91

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
DOCUMENT CHANGE NOTICE (DCN) RECORD

[1] Document Title:

Site Characterization Program Baseline

[2] Document Number:
YMP/CM-0011

NOTE: This document is revised by Section.

The document identified in Blocks 1 and 2 has been changed. The changed pages attached to this DCN are identified in Block 7 opposite the latest DCN number in Block 3. The original issue of this document as modified by all applicable DCN's constitutes the current version of the document identified in Blocks 1 and 2.

[3] DCN NO.	[4] CR NO.	[5] DOCUMENT Rev./ICN #	[6] CR TITLE	[7] AFFECTED PAGES	CHANGE	ADD	DELETE	[8] DATE
0	91/018	0	Initial Issue	All		X		2/22/91
1	91/052	1	Submit SCPB, Rev. 1 for CCB Control (complete revision of information related to ESF design)	All	X			4/5/91
2	91/110	2	Revision to Section 8.3.1.14 of the SCPB to Reflect Updated Plans in Study Plan 8.3.1.14.2	Table of Contents pages iii through xii Pages 8.3.1.14-1 through 8.3.1.14-52	X			10/2/91
3	91/096	3	Surface Dust Suppression water will not be tagged with chemical tracers	Table of Contents pages iii through xii for all 5 vols. 8.4.2-87		X		2/07/92
3	91/113	3	Addition of three large hydraulic gradient boreholes to the Yucca Mountain SCPB and add map (attachment 1)	8.3.1.2-251 8.3.1.2-253		X X		2/07/92
3	92/009	3	Change in objectives for Activities 1 and 4 of YMP-USGS Study Plan 8.3.1.2.1.4 (Regional Hydrologic System Synthesis and Modeling)	8.3.1.2-124 8.3.1.2-128	X X			
3	92/010	3	Change in title of Study 8.3.1.2.2.2 in SCPB	8.3.1.2-156	X			2/07/92

YMP-035-R0
4/22/91

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
DOCUMENT CHANGE NOTICE (DCN) RECORD

[1] Document Title:
Site Characterization Program Baseline

[2] Document Number:
YMP/CM-0011

The document identified in Blocks 1 and 2 has been changed. The changed pages attached to this DCN are identified in Block 7 opposite the latest DCN number in Block 3. The original issue of this document as modified by all applicable DCN's constitutes the current version of the document identified in Blocks 1 and 2.

[3] DCN NO.	[4] CR NO.	[5] DOCUMENT Rev./ICN #	[6] CR TITLE	[7] AFFECTED PAGES	CHANGE	ADD	DELETE	[8] DATE
3	92/020	3	Change title of activity 8.3.1.2.3.2.3	8.3.1.2-285	X			02/07/92
3	92/021	3	Change in objectives for activity 8.3.1.2.3.2.4 of YMP-USGS Study Plan 8.3.1.3.2 (Saturated zone hydrochemistry)	8.3.1.2-286	X			02/07/92
4	92/018	4	Change in objectives for Activity 8.3.1.2.3.2.3 of YMP-USGS Study Plan 8.3.1.2.3.2	8.3.1.2-285	X			03/13/92
4	92/019	4	Change in objectives for activity 8.3.1.2.3.2.1	8.3.1.2-281	X			03/13/92
5	92/093	5	Change title of activity in SCP 8.3.1.17.4.3.1 to SCP Activity 8.3.1.4.2.1	8.3.1.14-92 thru 8.3.1.17-99	X			07/15/92
6	92/095	6	Change Site Characterization Program Baseline (SCPB), Revision 6	All ESF related pages	X			07/15/92
7	92/094	7	Change of editorial (editorial corrections) to the SCPB, Sections 8.3.1.4.2.1.2 and 8.3.1.4.2.1.6	8.3.1.4-39 thru 8.3.1.4-54		X		07/15/92

NOTE: This document is revised by section.

YMP-035-R0
4/22/91

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
DOCUMENT CHANGE NOTICE (DCN) RECORD

[1] Document Title:

Site Characterization Program Baseline

[2] Document Number:

YMP/CM-0011

The document identified in Blocks 1 and 2 has been changed. The changed pages attached to this DCN are identified in Block 7 opposite the latest DCN number in Block 3. The original issue of this document as modified by all applicable DCN's constitutes the current version of the document identified in Blocks 1 and 2.

[3] DCN NO.	[4] CR NO.	[5] DOCUMENT Rev./ICN #	[6] CR TITLE	[7] AFFECTED PAGES	CHANGE	ADD	DELETE	[8] DATE
8	92/110	8	Change SCPB to Separate Man-Made material effects from near-Field Geochemistry	8.3.4.2-1-8.3.5 10-38	X			9/24/92
			Table of Contents change generated by above listed CR	Table of Contents: Changes noted In Revision Column	X			9/24/92
9	92/140	9	revisions to the SCPB	All	X			10/2/92
	NOTE:		**REVISION 9 STREAMLINES VOLUMES I THROUGH V OF THE SCPB INTO ONE VOLUME.**					

YMP-034-R2
11/13/91

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
CHANGE DIRECTIVE (CD)

[1] CR No. 92/140
Page 1 of 2

SECTION I. IDENTIFICATION

[2] Title of Change:
Revisions to the SCPB

[3] Change Classification:
☐ 0 ☒ 2
☐ 1 ☐ 3

SECTION II. DISPOSITION

[4] CR Disposition:
☒ Approved ☐ Approved with Conditions ☐ Disapproved

[5] Conditions: *(if applicable)*
None

(See Change Documentation Continuation Page ___)

[6] Implementation Direction: *(if applicable)*

1. This Change Request (CR) is approved to revise the Yucca Mountain Site Characterization Program Baseline (SCPB), YMP/CM-0011, Revision 9.

2. The CCB Secretary shall ensure that the Cover Page and the Title Page for Document Number YMP/CM-0011, Revision 9, are prepared.

3. The Document Originator shall provide a Print Ready Copy of YMP/CM-0011, Revision 9, to the CCB Secretary. The document number and revision number will be identified on each page of the Publication Ready Document

(See Change Documentation Continuation Page 2)

SECTION III. CONCURRENCE

All signatures below constitute procedural compliance. I have read, understood, and complied with Procedure QAP-5.1 Rev. 3 ICN # 2, in accomplishing my responsibilities in this procedure.

[7] Quality Assurance Organization Concurrence

Name: R. E. Spence (Print) Org.: YMQAD (Print)
Signature: R E Spence Date: 9/21/92

[8] Disposition Authority

Name: M. B. Blanchard (Print) Title: CCB Chrprsn (Print)
Signature: M B Blanchard Date: 9-21-92

[9] CD Effective Date
9/21/92

QMP-03-09

6 Implementation Direction (continued)

YMP/CM-0011, Revision 9. The Document Originator shall also provide a Document Change Notice (DCN) identifying changes made to Document YMP/CM-0011.

4. The CCB Secretary shall ensure that YMP/CM-0011, Revision 9, is prepared in accordance with this Change Directive (CD). The CCB Secretary shall prepare a Controlled Document Issuance Authorization (CDIA) to transmit this CD and YMP/CM-0011, Revision 9 to the Project Document Control Center (DCC) in accordance with AP-1.5Q.

5. Per AP-3.3Q, each Project Participant and Project Office Division Director will complete an Affected Document Notice (ADN) as notification of completion of implementation planning for this CD.

6. The CCB Secretary shall ensure that the Configuration Information System (CIS) and the CCB Document Register are updated to reflect this approved revision of Document YMP/CM-0011, Revision 9.

7. Any changes to Document YMP/CM-0011, Revision 9, will require submittal of a CR to the Project CCB.

8. Upon release of YMP/CM-0011, Revision 9, all Project Participants will be required to use YMP/CM-0011, Revision 9, in performing duties applicable to this document.

YMP-034-R2
11/13/91

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
CHANGE DIRECTIVE (CD)

1 CR No. 92/110
Page 1 of 2

SECTION I. IDENTIFICATION

2 Title of Change:

Change SCPB to Separate Man-Made material from Near-Field Geochemistry

3 Change Classification:

☐ 0 ☒ 2
☐ 1 ☐ 3

SECTION II. DISPOSITION

4 CR Disposition:

☒ Approved ☐ Approved with Conditions ☐ Disapproved

5 Conditions: *(if applicable)*

None

(See Change Documentation Continuation Page ___)

6 Implementation Direction: *(if applicable)*

1. CR:92/110, to the "Yucca Mountain Site Characterizarion Program Baseline (SCPB)", Document Number YMP/CM-0011, is approved. This change constitutes Revision 8.

2. The CCB Secretary shall ensure that the Cover page and Title page for Document YMP/CM-0011 are updated to reflect this approved change.

3. The document originator shall provide a publiction ready copy of YMP/CM-0011, to the CCB Secretary for processing. A revised Table of Contents

(See Change Documentation Continuation Page 2)

SECTION III. CONCURRENCE

All signatures below constitute procedural compliance. I have read, understood, and complied with Procedure QAP03-09, Rev. 3, ICN # 2, in accomplishing my responsibilities in this procedure.

7 Quality Assurance Organization Concurrence

Name: R. E. Spence (Print) Org.: YMQAD (Print)

Signature: R. E. Spence Date: 8/25/92

8 Disposition Authority

for Name: M. B. Blanchard (Print) Title: CCB Chrprsn (Print)

Signature: Robert M. Blanchard Date: 8/25/92

9 CD Effective Date

8/25/92

6 Implementation Direction (continued)

and Document Change Notice will also be included. The Docuemnt number and revision number will be identified on each page of the Publication Ready Document YMP/CM-0011.

4. The CCB Secretary shall ensure that YMP/CM-0011, Revision 8 is prepared in accordance with this Change Directive (CD). The CCB Secretary shall prepare a Controlled Document Issuance Authorization (CDIA) to transmit this CD and YMP/CM-0011, Revision 8, to the Project Document Control Center (DCC) in accordance with AP-1.5Q.

5. Per AP-3.3Q, each TPO and Project Office Division Director will complete an Affected Document Notice (ADN) as notificaion of completion of implementation planning for this CD.

6. The CCB Secretary shall ensure that the Configuration Information System (CIS) and the CCB Register are updated to reflect this approved revision.

7. Any changes to Document YMP/CM-0011 will require submission of a CR to the Project CCB.

8. Upon release of YMP/CM-0011, Revision 8, all Project Pariticipants will be required to use this revision in performing duties applicable to this document.

YMP-034-R2
11/13/91

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
CHANGE DIRECTIVE (CD)

[1] CR No. 92 095
Page 1 of 3

SECTION I. IDENTIFICATION

[2] Title of Change:
Site Characterization Program Baseline (SCPB) Revision 6

[3] Change Classification:
☐ 0 ☒ 2
☐ 1 ☐ 3

SECTION II. DISPOSITION

[4] CR Disposition:
☒ Approved ☐ Approved with Conditions ☐ Disapproved

[5] Conditions: *(if applicable)*
NONE

(See Change Documentation Continuation Page ___)

[6] Implementation Direction: *(if applicable)*

1. CR:92/095, is approved as Revision 6 to the "Yucca Mountain Site Characterization Program Baseline (SCPB)" Document Number YMP/CM-0011.

2. The CCB Secretary shall ensure that the Cover page and Title page for Document YMP/CM-0011 are updated to reflect this approved change.

3. The document originator shall provide a print ready copy of YMP/CM-0011, to the CCB Secretary for processing. A revised Table of Contents and Document Change Notice will also be included. The document number and revision number 6 will be

(See Change Documentation Continuation Page ___)

SECTION III. CONCURRENCE

All signatures below constitute procedural compliance. I have read, understood, and complied with Procedure 03-09, Rev. 3, ICN # 2, in accomplishing my responsibilities in this procedure.

[7] Quality Assurance Organization Concurrence

Name: R. E. Spence (Print) Org.: YMQAD (Print)
Signature: James Blaylock Date: 6/8/92

[8] Disposition Authority

Name: for M. B. Blanchard (Print) Title: CCB Chrprsn (Print)
Signature: Robert K. Bonta Date: 6/8/92

[9] CD Effective Date
6/8/92

6 Implementation Direction (continued)

identified on each page of the Publication Ready Document YMP/CM-0011.

4. The CCB Secretary shall ensure that YMP/CM-0011, Revision 6 is prepared in accordance with this Change Directive (CD). The CCB Secretary shall prepare a Controlled Document Issuance Authorization (CDIA) to transmit this CD and MP/CM-0011, Revision 6, to the Project Document Control Center (DCC) in accordance with AP-1.5Q

5. Per AP-3.3Q, each TPO and Project Office Division Director will complete an Affected Document Notice (ADN) as notification of completion of implementation planning for this CD.

6. The CCB Secretary shall ensure that the Configuration Information System (CIS) and the CCB Register are updated to reflect this approved addition of Document YMP/CM-0011.

7. Any changes to Document YMP/CM-0011 will require submission of a CR to the Prject CCB.

8. Upon release of YMP/CM-0011, Revision 6, all Project Participants will be required to use YMP/CM-0011, Revision 6, in performing duties applicable to this document.

YMP-034-R2
11/13/91

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT CHANGE DIRECTIVE (CD)

1 CR No. 92-094
Page 1 of 3

SECTION I. IDENTIFICATION

2 Title of Change:

Editorial Corrections to the SCPB, Sections 8.3.1.4.2.1.2 and 8.3.1.4.2.1.6

3 Change Classification:

☐ 0 ☒ 2
☐ 1 ☐ 3

SECTION II. DISPOSITION

4 CR Disposition:

☒ Approved ☐ Approved with Conditions ☐ Disapproved

5 Conditions: *(if applicable)*

NONE

(See Change Documentation Continuation Page ___)

6 Implementation Direction: *(if applicable)*

1. CR:92/094, is approved as Revision 7 to the "Yucca Mountain Site Characterizarion Program Baseline (SCPB)" Document Number YMP/CM-0011.

2. The CCB Secretary shall ensure that the Cover page and Title page for Document YMP/CM-0011 are updated to reflect this approved change.

3. The document originator shall provide a print ready copy of YMP/CM-0011, to the CCB Secretary for processing. A revised Table of Contents and Document Change Notice will also be included. The Docuemnt number and revision number 7 will be

(See Change Documentation Continuation Page ___)

SECTION III. CONCURRENCE

All signatures below constitute procedural compliance. I have read, understood, and complied with Procedure 03-69, Rev. 3, ICN # 2, in accomplishing my responsibilities in this procedure.

7 Quality Assurance Organization Concurrence

Name: R. E. Spence (Print) Org.: YMQAD (Print)

Signature: James Blaylock Date: 6/8/92

8 Disposition Authority

Name: M. B. Blanchard (Print) Title: CCB Chrprsn (Print)

Signature: Robert W Barton Date: 6/8/92

9 CD Effective Date

6/8/92

6 Implementation Direction (continued)

identified on each page of the Publication Ready Document YMN/CM-0011.

4. The CCB Secretary shall ensure that YMP/CM-0011, Revision 7 is prepared in accordance with this Change Directive (CD). The CCB Secretary shall prepare a Controlled Document Issuance Authorization (CDIA) to transmit this CD and YMP/CM-0011, Revision 7, to the Project Document Control Center (DCC) in accordance with AP-1.5Q.

5. Per AP-3.3Q, each TPO and Project Office Division Director will complete an Affected Document Notice (ADN) as notificaion of completion of implementation planning for this CD.

6. The CCB Secretary shall ensure that the Configuration Information System (CIS) and the CCB Register are updated to reflect this approved addition of Document YMP/CM-0011.

7. Any changes to Document YMP/CM-0011 will require submission of a CR to the Project CCB.

8. Upon release of YMP/CM-0011, Revision 7, all Project Pariticipants will be required to use YMP/CM-0011, Revision 7, in performing duties applicable to this document.

INFORMATION COPY DAM 6-11-92 ~~INFORMATION COPY~~

YMP-034-R2
11/13/91

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
CHANGE DIRECTIVE (CD)

1 CR No. 92/093
Page 1 of 2

SECTION I. IDENTIFICATION

2 Title of Change:

Add Activity in SCP 8.3.1.17.4.3.1 to SCP Activity 8.3.1.4.2.1

3 Change Classification:

☐ 0 ☒ 2
☐ 1 ☐ 3

SECTION II. DISPOSITION

4 CR Disposition:

☒ Approved ☐ Approved with Conditions ☐ Disapproved

5 Conditions: *(if applicable)*

NONE

(See Change Documentation Continuation Page ___)

6 Implementation Direction: *(if applicable)*

1. CR:92/093, is approved as revision 5 to the "Yucca Mountain Site Characterization Program Baseline (SCPB)" Document Number YMP/CM-0011.

2. The CCB Secretary shall ensur that the Cover page and Title page for Document Number YMP/CM-0011 are updated to reflect this approved change.

3. The document originator shall provide a print ready copy of YMP/CM-0011, to the CCB Secretary for processing. A revised table of Contents and Document Change Notice will also be included. The document number and revision number 5 will be

(See Change Documentation Continuation Page ___)

SECTION III. CONCURRENCE

All signatures below constitute procedural compliance. I have read, understood, and complied with Procedure 03-09, Rev. 3, ICN # 2, in accomplishing my responsibilities in this procedure.

7 Quality Assurance Organization Concurrence

Name: R. E. Spence (Print) Org.: YMQAD (Print)

Signature: for James Blaylock Date: 6/8/92

8 Disposition Authority

Name: for M. B. Blanchard (Print) Title: CCB Chrprsn (Print)

Signature: Robert K. Barton Date: 6/8/92

9 CD Effective Date

6/8/92

6 Implementation Direction (continued)

identified on each page of the Publication Ready Document YMP/CM-0011.

4. The CCB Secretary shall ensure that YMP/CM-0011, Revision 5 is prepared in accordance with this Change Directive (CD). The CCB Secretary shall prepare a Controlled Document Issuance Authorization (CDIA) to transmit this CD and YMP/CM-0011, Revision 5, to the Project Document Control Center (DCC) in accordance with AP-1.5Q.

5. Per AP-3.3Q, each TPO and Project Office Division Director will complete an Affected Document Notice (ADN) as notification of completion of implementation planning for this CD.

6. The CCB Secretary shall ensure that the Configuration Information System (CIS) and the CCB Register are updated to reflect this approved addition of Document YMP/CM-0011.

7. Any changes to Document YMP/CM-0011 will require submission of a CR to the Project CCB.

8. Upon release of YMP/CM-0011, Revision 5, all Project Participants will be required to use YMP/CM-0011, Revision 5, in performing duties applicable to this document.

YMP-034-R2
11/13/91

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
CHANGE DIRECTIVE (CD)

1 CR No. 92/021
Page 1 of 2

SECTION I. IDENTIFICATION

2 Title of Change:

Change in objectives for activity 8.3.1.2.3.2.4 of YMP-USGS SP 8.3.1.2.3.2 (saturated-zone hydrochemistry)

3 Change Classification:

☐ 0 ☒ 2
☐ 1 ☐ 3

SECTION II. DISPOSITION

4 CR Disposition:

☒ Approved ☐ Approved with Conditions ☐ Disapproved

5 Conditions: *(if applicable)*

None

(See Change Documentation Continuation Page ___)

6 Implementation Direction: *(if applicable)*

1. CR:92/021, is approved as the "Yucca Mountain Site Characterization Program Baseline (SCPB)" Document Number YMP/CM-0011.

2. The CCB Secretary shall ensure that the Cover page and Title page for Document YMP/CM-0011 are updated to reflect this approved change.

3. The Director, RSED shall provide a print ready copy of YMP/CM-0011, to the CCB Secretary for processing. A revised Table of Contents and Document Change Notice will also be included. The document number and revision

(See Change Documentation Continuation Page 2)

SECTION III. CONCURRENCE

All signatures below constitute procedural compliance. I have read, understood, and complied with Procedure QAP-03-09, Rev. 3, ICN # 1, in accomplishing my responsibilities in this procedure.

7 Quality Assurance Organization Concurrence

Name: R. E. Spence (Print) Org.: YMQAD (Print)

Signature: R E Spence Date: 11/4/92

8 Disposition Authority

Name: for M. B. Blanchard (Print) Title: CCB Chrprsn (Print)

Signature: Robert H Barton Date: 11/4/92

9 CD Effective Date

1/14/92

6 Implementation Direction (continued)

number will be identified on each page of the Publication Ready Document YMP/CM-0011.

4. In addition to all affected Project Participants, the PCB Chief, the Directors of EDD, P&OCD, RSED and YMSO will complete an Affected Document Notice (ADN) for implementation planning.

5. The CCB Secretary shall ensure that the Configuration Information System (CIS) and the CCB Register are updated to reflect this approved addition of Document YMP/CM-0011.

6. Any changes to Document YMP/CM-0011 will require submission of a CR to the Project CCB.

YMP-034-R2
11/13/91

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
CHANGE DIRECTIVE (CD)

1 CR No. 92/020
Page 1 of 2

SECTION I. IDENTIFICATION

2 Title of Change:
Activity 8.3.1.2.3.2.3 Title Change

3 Change Classification:
☐ 0 ☒ 2
☐ 1 ☐ 3

SECTION II. DISPOSITION

4 CR Disposition:
☒ Approved ☐ Approved with Conditions ☐ Disapproved

5 Conditions: *(if applicable)*
None

(See Change Documentation Continuation Page ___)

6 Implementation Direction: *(if applicable)*

1. CR:92/020, is approved as the "Yucca Mountain Site Characterization Program Baseline (SCPB)" Document Number YMP/CM-0011.

2. The CCB Secretary shall ensure that the Cover page and Title page for Document YMP/CM-0011 are updated to reflect this approved change.

3. The Director, RSED shall provide a print ready copy of YMP/CM-0011, to the CCB Secretary for processing. A revised Table of Contents will also be included. The document number and revision number will be identified

(See Change Documentation Continuation Page 2)

SECTION III. CONCURRENCE

All signatures below constitute procedural compliance. I have read, understood, and complied with Procedure AP-3.3Q, Rev. 4, ICN # 2, in accomplishing my responsibilities in this procedure.

7 Quality Assurance Organization Concurrence

Name: R. E. Spence (Print) Org.: YMQAD (Print)
Signature: R. E. Spence Date: 12/30/91

8 Disposition Authority

Name: for M. B. Blanchard (Print) Title: CCB Chrprsn (Print)
Signature: Robert W. Dutton Date: 12/30/91

9 CD Effective Date
12/30/91

6 Implementation Direction (continued)

on each page of the Publication Ready Document YMP/CM-0011.

4. In addition to all affected Project Participants, the PCB Chief, the Directors of EDD, P&OCD, RSED and YMSO will complete an Affected Document Notice (ADN) for implementation planning.

5. The CCB Secretary shall ensure that the Configuration Information System (CIS) and the CCB Register are updated to reflect this approved addition of Document YMP/CM-0011.

6. Any changes to Document YMP/CM-0011 will require submission of a CR to the Project CCB.

YMP-034-R2
11/13/91

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
CHANGE DIRECTIVE (CD)

1 CR No. 92/019
Page 1 of 2

SECTION I. IDENTIFICATION

2 Title of Change:

Change in objectives for activity 8.3.1.2.3.2.1 of YMP-USGS SP 8.3.1.2.3.2 (saturated-zone hydrochemistry)

3 Change Classification:

☐ 0 ☒ 2
☐ 1 ☐ 3

SECTION II. DISPOSITION

4 CR Disposition:

☒ Approved ☐ Approved with Conditions ☐ Disapproved

5 Conditions: *(if applicable)*

None

(See Change Documentation Continuation Page ___)

6 Implementation Direction: *(if applicable)*

1. CR:92/019, is approved as revision to the "Yucca Mountain Site Characterization Program Baseline (SCPB)" Document Number YMP/CM-0011.

2. The CCB Secretary shall ensure that the Cover page and Title page for Document YMP/CM-0011 are updated to reflect this approved change.

3. The Director, RSED shall provide a print ready copy of YMP/CM-0011, to the CCB Secretary for processing. The document number and revision number will be identified on each page of the Publication Ready Document YMP/CM-0011. A

(See Change Documentation Continuation Page 2)

SECTION III. CONCURRENCE

All signatures below constitute procedural compliance. I have read, understood, and complied with Procedure QMP-03-09, Rev. 3, ICN # 2, in accomplishing my responsibilities in this procedure.

7 Quality Assurance Organization Concurrence

Name: R. E. Spence (Print) Org.: YMQAD (Print)

Signature: _____ Date: _____

8 Disposition Authority

Name: for M. B. Blanchard (Print) Title: CCB Chrprsn (Print)

Signature: Robert F. Barton Date: 2/10/92

9 CD Effective Date

2/10/92

6 Implementation Direction (continued)

revised Table of Contents and Document Change Notice will also be included.

4. In addition to all affected Project Participants, the PCB Chief, the Directors of EDD, P&OCD, RSED and YMPO will complete an Affected Document Notice (ADN) for implementation planning.

5. The CCB Secretary shall ensure that the Configuration Information System (CIS) and the CCB Register are updated to reflect this approved revision to Document YMP/CM-0011.

6. Any changes to Document YMP/CM-0011 will require submission of a CR to the Project CCB.

YMP-034-R2
11/13/91

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
CHANGE DIRECTIVE (CD)

[1] CR No. 92/018
Page 1 of 2

SECTION I. IDENTIFICATION

[2] Title of Change:

Change in objectives for activity 8.3.1.2.3.2.3 of YMP-USGS SP 8.3.1.2.3.2 (saturated-zone hydrochemistry)

[3] Change Classification:

☐ 0 ☒ 2
☐ 1 ☐ 3

SECTION II. DISPOSITION

[4] CR Disposition:

☒ Approved ☐ Approved with Conditions ☐ Disapproved

[5] Conditions: *(if applicable)*

None

(See Change Documentation Continuation Page ___)

[6] Implementation Direction: *(if applicable)*

1. CR:92/018, is approved as revision to the "Yucca Mountain Site Characterization Program Baseline (SCPB)" Document Number YMP/CM-0011.

2. The CCB Secretary shall ensure that the Cover page and Title page for Document YMP/CM-0011 are updated to reflect this approved change.

3. The Director, RSED shall provide a print ready copy of YMP/CM-0011, to the CCB Secretary for processing. The document number and revision number will be identified on each page of the Publication Ready Document YMP/CM-0011. A

(See Change Documentation Continuation Page 2)

SECTION III. CONCURRENCE

All signatures below constitute procedural compliance. I have read, understood, and complied with Procedure QMP-03-09, Rev. 3, ICN # 12, in accomplishing my responsibilities in this procedure.

[7] Quality Assurance Organization Concurrence

Name: R. E. Spence *(Print)* Org.: YMQAD *(Print)*

Signature: R. E. Spence Date: 2/7/92

[8] Disposition Authority

Name: M. B. Blanchard *(Print)* Title: CCB Chrprsn *(Print)*

Signature: Robert M. Blanchard Date: 2/10/92

[9] CD Effective Date

2/10/92

6 Implementation Direction (continued)

revised Table of Contents and Document Change Notice will also be included.

4. In addition to all affected Project Participants, the PCB Chief, the Directors of EDD, P&OCD, RSED and YMSO will complete an Affected Document Notice (ADN) for implementation planning.

5. The CCB Secretary shall ensure that the Configuration Information System (CIS) and the CCB Register are updated to reflect this approved revision to Document YMP/CM-0011.

6. Any changes to Document YMP/CM-0011 will require submission of a CR to the Project CCB.

YMP-034-R2
11/13/91

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
CHANGE DIRECTIVE (CD)

SECTION I. IDENTIFICATION

2 Title of Change:
Change of Title of Study 8.3.1.2.2.2 in SCPB

3 Change Classification:
☐ 0 ☒ 2
☐ 1 ☐ 3

SECTION II. DISPOSITION

4 CR Disposition:
☒ Approved ☐ Approved with Conditions ☐ Disapproved

5 Conditions: *(if applicable)*
None

(See Change Documentation Continuation Page ___)

6 Implementation Direction: *(if applicable)*

1. CR:92/010, is approved as the "Yucca Mountain Site Characterization Program Baseline (SCPB)" Document Number YMP/CM-0011, Revision 3.

2. The CCB Secretary shall ensure that the Cover page and Title page for Document YMP/CM-0011, Revision 3, are updated to reflect this approved change.

3. The Director, RSED shall provide a print ready copy of YMP/CM-0011, Revision 3, to the CCB Secretary for processing. A revised Table of Contents will

(See Change Documentation Continuation Page 2)

SECTION III. CONCURRENCE

All signatures below constitute procedural compliance. I have read, understood, and complied with Procedure QMP-03-09 Rev. 3, ICN #2 in accomplishing my responsibilities in this procedure.

7 Quality Assurance Organization Concurrence

Name: R. Spence (Print) Org.: YMQAD (Print)
Signature: R. E. Spence Date: 12/12/91

8 Disposition Authority

Name: M. B. Blanchard (Print) Title: CCB Chrprsn (Print)
Signature: Robert M. Barton Date: 12/12/91

9 CD Effective Date
12/12/91

6 Implementation Direction (continued)

also be included. The document number and revision number will be identified on each page of the Publication Ready Document YMP/CM-0011, Revision 3.

4. In addition to all affected Project Participants, the PCB Chief, the Directors of EDD, P&OCD, RSED and YMSO will complete an Affected Document Notice (ADN) for implementation planning.

5. The CCB Secretary shall ensure that the Configuration Information System (CIS) and the CCB Register are updated to reflect this approved addition of Document YMP/CM-0011, Revision 3.

6. Any changes to Document YMP/CM-0011, Revision 3, will require submission of a CR to the Project CCB.

YMP-034-R2
11/13/91

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
CHANGE DIRECTIVE (CD)

[1] CR No. 92/009

SECTION I. IDENTIFICATION

[2] Title of Change:

Change in Objectives for Activities 1 and 4 of YMP USGS Study Plan 8.3.1.2.1.4 (Regional Hydrologic System Synthesis and Modeling)

[3] Change Classification:

☐ 0 ☒ 2
☐ 1 ☐ 3

SECTION II. DISPOSITION

[4] CR Disposition:

☒ Approved ☐ Approved with Conditions ☐ Disapproved

[5] Conditions: *(if applicable)*

None

(See Change Documentation Continuation Page ___)

[6] Implementation Direction: *(if applicable)*

1. CR:92/009, is approved as the "Yucca Mountain Site Characterization Program Baseline (SCPB)" Document Number YMP/CM-0011, Revision 3.

2. The CCB Secretary shall ensure that the Cover page and Title page for Document YMP/CM-0011, Revision 3, are updated to reflect this approved change.

3. The Director, RSED shall provide a print ready copy of YMP/CM-0011, Revision 3, to the CCB Secretary for processing. A revised Table of Contents will

(See Change Documentation Continuation Page 2)

SECTION III. CONCURRENCE

All signatures below constitute procedural compliance. I have read, understood, and complied with Procedure _____, Rev. ___, ICN # ___ in accomplishing my responsibilities in this procedure.

[7] Quality Assurance Organization Concurrence

Name: R. Spence (Print) Org.: YMQAD (Print)

Signature: R. E. Spence Date: 12/12/91

[8] Disposition Authority

Name: for M. B. Blanchard (Print) Title: CCB Chrprsn (Print)

Signature: Robert F. Burton Date: 12/12/91

[9] CD Effective Date

6 Implementation Direction (continued)

also be included. The document number and revision number will be identified on each page of the Publication Ready Document YMP/CM-0011, Revision 3.

4. In addition to all affected Project Participants, the PCB Chief, the Directors of EDD, P&OCD, RSED and YMSO will complete an Affected Document Notice (ADN) for implementation planning.

5. The CCB Secretary shall ensure that the Configuration Information System (CIS) and the CCB Register are updated to reflect this approved addition of Document YMP/CM-0011, Revision 3.

6. Any changes to Document YMP/CM-0011, Revision 3, will require submission of a CR to the Project CCB.

INFORMATION ONLY

YMP-034-R1
9/16/91

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
CHANGE DIRECTIVE (CD)

[1] CR No. 91/113
Page 1 of 2

SECTION I. IDENTIFICATION

[2] Title of Change:

Addition of Three Large Hydraulic Gradient Boreholes to the Yucca Mountain Site Characterization Program Baseline

[3] Change Classification:

☐ 0 ☒ 2
☐ 1 ☐ 3

SECTION II. DISPOSITION

[4] CR Disposition:

☐ Approved ☒ Approved with Conditions ☐ Disapproved

[5] Conditions: *(if applicable)*

1. Cost and Schedule impacts and changes to planning documents for implementing the proposed work shall be prepared and approved prior to commencement of work.

2. Grading Packages for proposed work must be prepared and approved prior to the commencement of proposed work.

(See Change Documentation Continuation Page ___)

[6] Implementation Direction: *(if applicable)*

1. CR:91/113, is approved with the above conditions as the "Yucca Mountain Site Characterization Program Baseline (SCPB)" Document Number YMP/CM-0011, Rev 5.

2. The CCB Secretary shall ensure that the cover page and Title page for Document YMP/CM-0011, Rev 5 are updated to reflect this approved change.

3. The Director, RSED shall provide a print ready copy of YMP/CM-0011 to the CCB Secretary for processing upon the completion of condition #1. A

(See Change Documentation Continuation Page 2)

SECTION III. CONCURRENCE

[7] Quality Assurance Organization Concurrence

Name: R. E. Spence (Print) Org.: PQA (Print)
Signature: R E Spence Date: 10/31/91

[8] Disposition Authority

for
Name: M. B. Blanchard (Print) Title: CCB Chrprsn (Print)
Signature: Robert W Barnard Date: 10/31/91

[9] CD Effective Date

10/31/91

OMB 03.09

6 Implementation Direction (continued)

revised table of contents will also be included. The document number and revision number will be identified on each page of the publication ready document YMP/CM-0011, Rev 5.

4. The Director, RSED will ensure the integration of the three new boreholes into the integrated drilling schedule.

5. REECo and USGS will assess the cost and schedule impacts for the three new boreholes and initiate C/SCRs as appropriate in accordance with AP-3.7.

6. In addition to all affected Project Participants, the PCB Chief, the Directors of EDD, P&OCD, RSED and YMSO will complete an Affected Document Notice (ADN) for implementation planning.

7. The CCB Secretary shall ensure that the Configuration Information System (CIS) and the CCB Register are updated to reflect this approved addition of Document YMP/CM-0011.

8. Any changes to Document YMP/CM-0011 will require submission of a CR to the Project CCB.

YMP-034-R1
9/16/91

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
~~CHANGE DIRECTIVE (CD)~~

[1] CR No. 91/110
Page 1 of 2

SECTION I. IDENTIFICATION

[2] Title of Change:

Revision to Section 8.3.1.14 of the SCPB to Reflect Updated Plans in Study Plan 8.3.1.14.2

[3] Change Classification:

☐ 0 ☒ 2
☐ 1 ☐ 3

SECTION II. DISPOSITION

[4] CR Disposition:

☒ Approved ☐ Approved with Conditions ☐ Disapproved

[5] Conditions: *(if applicable)*

None

(See Change Documentation Continuation Page ___)

[6] Implementation Direction: *(if applicable)*

1. This Change Request (CR) for the Site Chararacterization Program Baseline, Revision "A," Document Number YMP/CM-0011 is approved.
   2 SCT 10/1/91
2. The CCB Secretary shall ensure that the Title Page for Document YMP/CM-0011 Revision A, are prepared.
   2 SCT 10/1/91
3. The Document Originator shall provide a Print Ready Copy of YMP/CM-0011, Revision A, to the CCB Secretary. The Document Number and Revision Number
   SCT 10/1/91

(See Change Documentation Continuation Page 2)

SECTION III. CONCURRENCE

[7] Quality Assurance Organization Concurrence

Name: D. G. Horton (Print) Org.: PQA (Print)

Signature: Catherine Hampton for Date: 9-24-91

[8] Disposition Authority

Name: for M. B. Blanchard (Print) Title: CCB Chrprsn (Print)

Signature: Robert F. Pasten Date: 9/25/91

[9] CD Effective Date

9/25/91

6 Implementation Direction (continued)

will be identified on each page of the Publication Ready Document, YMP/CM-0011. The Document Originator shall also provide a Document Change Notice (DCN) indicating changes made to the document.

4. The CCB Secretary shall ensure that YMP/CM-0011, Revision ~~4~~ 2 SCT 10/1/91, is prepared in accordance with this Change Directive (CD). The CCB Secretary shall prepare a Controlled Document Issuance Authorization (CDIA) to transmit this CD, the DCN, and YMP/CM-0011, Revision ~~4~~ 2 SCT 10/1/91, to the Project Document Control Center (DCC) in accordance with AP-1.5Q.

5. Per AP-3.3Q, each TPO and Project Office Division Director will complete an Affected Document Notice (ADN) as notification of completion of implementation planning for this CD.

6. The CCB Secretary shall ensure that the Configuration Information System (CIS) and the CCB Register are updated to reflect Revision ~~4~~ 2 SCT 10/1/91 to YMP/CM-0011.

7. Any changes to document YMP/CM-0011, Revision ~~4~~ 2 SCT 10/1/91, will require submittal of a CR to the Project CCB.

8. Upon release of YMP/CM-0011, Revision ~~4~~ 2 SCT 10/1/91, all Project Participants will be required to use YMP/CM-0011, Revision ~~4~~ 2, in performing duties applicable to this document.

YMP-034-R0
4/22/91

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT
CHANGE DIRECTIVE (CD)

[1] CR No. 91/096
Page 1 of 2

SECTION I. IDENTIFICATION

[2] Title of Change:

SCPB Revision: Surface Dust Suppression Water will not be tagged wtih a Chemical Tracer

[3] Change Classification:
☐ Class 1 ☐ Class 3
☒ Class 2

SECTION II. DISPOSITION

[4] CR Disposition:
☐ Approved ☐ Disapproved
☒ Approved with Conditions

[5] Conditions: *(if applicable)*

1. The revision to the SCPB Document must undergo a QMP-06-04 Management, QA and Technical review.

(See Change Documentation Continuation Page ___)

[6] Implementation Direction: *(if applicable)*

1. This Change Request (CR) for the Site Chararacterization Program Baseline, Revision 3," Document Number YMP/CM-0011 is approved with the condition listed in Block 5 of the CD.

2. The CCB Secretary shall ensure that the Title Page for Document YMP/CM-0011 Revision 3, are prepared.

3. The Document Originator shall provide a Print Ready Copy of YMP/CM-0011,

(See Change Documentation Continuation Page 2)

SECTION III. CONCURRENCE

[7] Quality Assurance Organization Concurrence

Name: D. G. Horton (print) Org.: PQA (print)
Signature: Catherine Hampton for Date: 8-21-91

[8] Disposition Authority

Name: M. B. Blanchard (print) Title: CCB Chrprsn (print)
Signature: M. Blanchard Date: 8-21-91

[9] CD Effective Date

8/21/91

6 Implementation Direction (continued)

Revision 3, to the CCB Secretary. The Document Number and Revision Number will be identified on each page of the Publication Ready Document, YMP/CM-0011. The Document Originator shall also provide a Document Change Notice (DCN) indicating changes made to the document.

4. The CCB Secretary shall ensure that YMP/CM-0011, Revision 3, is prepared in accordance with this Change Directive (CD). The CCB Secretary shall prepare a Controlled Document Issuance Authorization (CDIA) to transmit this CD, the DCN, and YMP/CM-0011, Revision 3, to the Project Document Control Center (DCC) in accordance with AP-1.5Q.

5. Per AP-3.3Q, each TPO and Project Office Division Director will complete an Affected Document Notice (ADN) as notification of completion of implementation planning for this CD.

6. The CCB Secretary shall ensure that the Configuration Information System (CIS) and the CCB Register are updated to reflect Revision 3 to YMP/CM-0011.

7. Any changes to document YMP/CM-0011, Revision 3, will require submittal of a CR to the Project CCB.

8. Upon release of YMP/CM-0011, Revision 3, all Project Participants will be required to use YMP/CM-0011, Revision 3, in performing duties applicable to this document.

Y-AD-057
9/90

YUCCA MOUNTAIN PROJECT
CHANGE DIRECTIVE (CD)

[1] CR No. 91/052
Page 1 of 2

SECTION I. IDENTIFICATION

[2] Title of Change:

Submittal of the "Site Characterization Program Baseline, Rev. 1," for CCB Control

[3] Change Classification:

☐ Class 1 ☐ Class 3
☒ Class 2

SECTION II. DISPOSITION

[4] CR Disposition:

☐ Approved ☐ Disapproved
☒ Approved with Conditions

[5] Conditions: *(if applicable)*

The next revision of this document should incorporate the following items:

1. The term "Exploratory Shaft Facility" should be replaced by "Exploratory Studies Facility" throughout the document.

2. The term "repository" should be replaced by "potential repository" throughout the document.

(See Change Documentation Continuation Page ___)

[6] Implementation Direction: *(if applicable)*

1. This Change Request (CR) is approved for CCB Baselining as the "Site Characterization Program Baseline, Revision 1," and is assigned Controlled Document number YMP/CM-0011.

2. The Director, Regulatory and Site Evaluation Division is responsible for ensuring the above listed conditions are incorporated into the next revision of Document YMP/CM-0011.

(See Change Documentation Continuation Page 2)

SECTION III. CONCURRENCE

[7] Quality Assurance Organization Concurrence

Name: D. G. Horton (print) Org.: PQA (print)
Signature: N Valdivia for DG Horton Date: 3/28/91

[8] Disposition Authority

Name: M. B. Blanchard (print) Title: CCB Chrprsn (print)
Signature: Robert W Forton For Maxwell Blanchard Date: 3/28/91

[9] Effective Date: 3/28/91

6 Implementation Direction (continued)

3. The CCB Secretary shall ensure that the Cover Page and the Title Page for Document YMP/CM-0011, Revision 1, are prepared.

4. The Document Originator shall provide a Print Ready Copy of YMP/CM-0011, Revision 1, to the CCB Secretary. The Document Number and Revision Number will be identified on each page of the Publication Ready Document, YMP/CM-0011.

5. The CCB Secretary shall ensure that YMP/CM-0011, Revision 1, is prepared in accordance with this Change Directive (CD). The CCB Secretary shall ensure the Document Change Notice (DCN), indicating changes made in the document, is prepared. The DCN will be attached to the front of the Print Ready Copy of the document. The CCB Secretary shall also prepare a Controlled Document Issuance Authorization (CDIA) to transmit this CD, the DCN, and YMP/CM-0011, Revision 1, to the Project Document Control Center (DCC) in accordance with AP-1.5Q.

6. Per AP-3.3Q, each TPO and Project Office Division Director will complete an Affected Document Notice (ADN) as notification of completion of implementation planning for this CD.

7. The CCB Secretary shall ensure that the Configuration Information System (CIS) and the CCB Register are updated to reflect Revision 1 to YMP/CM-0011.

8. Any changes to document YMP/CM-0011, Revision 1, will require submittal of a CR to the Project CCB.

9. Upon release of YMP/CM-0011, Revision 1, all Project Participants will be required to use YMP/CM-0011, Revision 1, in performing duties applicable to this document.

Y-AD-057
9/90

YUCCA MOUNTAIN PROJECT
CHANGE DIRECTIVE (CD)

[1] CR No. 91/018
Page 1 of 2

SECTION I. IDENTIFICATION

[2] Title of Change:

PROPOSED BASELINING OF THE YM SITE CHARACTERIZATION PROGRAM (SCP CHP. 8, PART B, VOL. IV-VIII)

[3] Change Classification:
☐ Class 1 ☐ Class 3
☒ Class 2

SECTION II. DISPOSITION

[4] CR Disposition:

☐ Approved ☐ Disapproved
☒ Approved with Conditions

[5] Conditions: *(if applicable)*

1. Review of all Project Office controlled documents will be completed to identify references to the:
   - Technical Planning Basis (TPB): SCP Yucca Mountain Site, Nevada Research and Development Area, YMP/CC-0005, Rev. 0, 9/90.
   - Test and Evaluation Planning Basis (T&EPB), Volumes 1-4, YMP/90-23, Rev. 0, 8/90.

   The references will be replaced by references to the Site Characterization Program Baseline (SCPB).

2. The Director, RSED will ensure, prior to issuance, that the following changes have been incorporated into the SCPB:

(See Change Documentation Continuation Page 2)

[6] Implementation Direction: *(if applicable)*

1. CR 91/018 is approved with the above conditions as the "Yucca Mountain Site Characterization Program Baseline (SCPB)" and is assigned document number YMP/CM-0011, Rev. 0, (Configuration Identification number CI.13.0000). YMP/CM-0011 supersedes YMP/CC-0005, Rev. 0 and replaces the need for the T&EPB.

2. The CCB Secretary shall ensure that the Cover Page and Title Page for Document YMP/CM-0011, Rev. 0 are updated to reflect this approved change.

(See Change Documentation Continuation Page 2)

SECTION III. CONCURRENCE

[7] Quality Assurance Organization Concurrence

Name: D. G. Horton (print) Org.: PQA (print)
Signature: N Valdivia for Date: 12/14/90

[8] Disposition Authority

Name: M. B. Blanchard (print) Title: Acting DPM (print)
Signature: Maxwell Blanchard Date: 12-14-90

[9] Effective Date:
12/14/90

5 Condition (continued)

- SCP Sections 8.5 and 8.6 will be excluded.
- All milestones, schedules, decision points, and procedures in the SCP will be excluded.
- Changes identified in CR 90/031 will be incorporated.
- The errata sheet for references to the SCP will be incorporated.
- The Glossary in Volume VIII of the SCP will be appended to the SCPB prior to controlled distribution.

6 Implementation Direction (continued)

3. The RSED Director will provide a print ready copy of YMP/CM-0011 to the CCB Secretary for processing upon completion of Condition #2. A revised Table of Contents will also be included. The document number and revision number will be identified on each page of the publication ready document (YMP/CM-0011, Rev. 0).

4. In addition to all affected Project Participants, the PCB Chief will complete an Affected Document Notice [(ADN) Form Y-AD-001, 4/90] after review of all project plans, APs, QMPs, and BTPs to meet Condition 1.

5. In addition to all affected Project Participants, the Directors of EDD, P&OCD, and RSED will complete an ADN after review of all technical requirements documents under their cognizance to meet Condition 1.

6. The CCB Secretary shall ensure that the Configuration Information System (CIS) and the CCB Register are updated to reflect this approved addition of Document YMP/CM-0011.

7. Any changes to Document YMP/CM-0011 will require submission of a CR to the Project CCB.

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

SITE CHARACTERIZATION PROGRAM BASELINE

REVISION 9

AUGUST 1992

Prepared for

U.S. Department of Energy
Office of Civilian Radioactive Waste Management

Prepared for the Yucca Mountain Site Characterization Project as part of the Civilian Radioactive Waste Management Program. The Yucca Mountain Site Characterization Project is managed by the Yucca Mountain Site Characterization Project Office of the U.S. Department of Energy. The Yucca Mountain Site Characterization Project work is sponsored by the U.S. Department of Energy Office of Civilian Radioactive Waste Management.

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

SITE CHARACTERIZATION PROGRAM BASELINE

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Title

SITE CHARACTERIZATION PROGRAM BASELINE

TBD LOG

DOCUMENT/REVISION NUMBER 9

SECTION OR PARAGRAPH	RESPONSIBLE ORGANIZATION	SCHEDULE RESOLUTION DATE	BRIEF DESCRIPTION

NONE

Title

SITE CHARACTERIZATION PROGRAM BASELINE...

DATA TO BE VERIFIED/VALIDATED LOG

DOCUMENT/REVISION NUMBER 9

SECTION OR PARAGRAPH	VERICATION/ VALIDATION ORGANIZATION	VERIFICATION/ VALIDATION SCHEDULE DATE	BRIEF DESCRIPTION

NONE

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

SITE CHARACTERIZATION PROGRAM BASELINE

LIST OF FIGURES

YUCCA MOUNTAIN SITE CHARACTERIZATION PROJECT

SITE CHARACTERIZATION PROGRAM BASELINE

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8.1 INTENTIONALLY OMITTED

8.2 INTENTIONALLY OMITTED

8.3 PLANNED STUDIES AND PERFORMANCE ALLOCATION TABLES

8.3.1 SITE PROGRAM

8.3.1.1 Overview

This section describes the site characterization investigations currently thought to be necessary to adequately characterize the Yucca Mountain site. The investigations are subdivided into studies and activities. The studies and activities will be described in further detail in study plans. The site data base developed by the planned studies will be used to meet the requirements specified for the performance and design issues presented in Sections 8.3.2 through 8.3.5. The site information to be collected in this program will serve as a part of the basis for determining if the regulatory requirements for licensing a geologic repository can be met at the Yucca Mountain site.

8.3.1.2 Objectives of the geohydrology program

The performance issues that require data from this site characterization program are discussed, together with the current strategy that the YMP intends to use in the conduct of this site characterization program. The investigations and studies to be conducted are identified.

The major part of Section 8.3.1.2 provides the objectives of the studies and activities that have been chosen to provide the information required by the characterization investigations. The test program directly relates to performance requirements identified in 40 Code of Federal Regulations (CFR) Part 191 and 10 CFR Part 60, specifically the following:

40 CFR 191.13(a)

> Disposal systems for spent nuclear fuel or high-level or trans-uranic radioactive wastes shall be designed to provide a reasonable expectation, based upon performance assessment, that the cumulative releases of radionuclides to the accessible environment for 10,000 yr after disposal from all significant processes and events, that may affect the disposal system shall:
>
> (1) Have a likelihood of less than one chance in 10 of exceeding the quantities calculated according to Table 1 (Appendix A); and
>
> (2) Have a likelihood of less than one chance in 1,000 of exceeding ten times the quantities calculated according to Table 1 (Appendix A).

40 CFR 191.16(b)

> Disposal systems for spent nuclear fuel or high-level or transuranic radioactive wastes shall be designed to provide a reasonable expectation, that for 1,000 yr after disposal, undisturbed performance of the disposal system shall not cause the radionuclide concentrations averaged over any year in water withdrawn from any portion of a special source of ground water to exceed:

(1) Five picocuries per liter of radium-226 and radium-228;

(2) Fifteen picocuries per liter of alpha-emitting radionuclides (including radium-226 and radium-228 but excluding radon); or

(3) The combined concentrations of radionuclides, that emit either beta or gamma radiation that would produce an annual dose equivalent to the total body or any internal organ >4 rems/yr if an individual consumed 2 L/day of drinking water from such a source of ground water.

10 CFR 60.113 (a)(1)(ii)(A)

Containment of high-level waste within the waste package will be substantially complete for a period to be determined (TBD) by the Commission taking into account the factors specified in Part 60.113(b) provided that such period shall be not less than 300 yr nor more than 1,000 yr after permanent closure of the geologic repository.

10 CFR 60.113 (a)(1)(ii)(B)

The release rate of any radionuclide from the engineered barrier system (EBS) following the containment period shall not exceed one part in 100,000/yr of the inventory of that radionuclide calculated to be present at 1,000 yr following permanent closure, or such fraction of the inventory as may be approved or specified by the Commission; provided, that this requirement does not apply to any radionuclide which is released at a rate <0.1 percent of the calculated total release rate limit. The calculated total release rate limit shall be taken to be one part in 100,000/yr of the inventory of radioactive waste, originally emplaced in the underground facility, that remains after 1,000 yr of radioactive decay.

10 CFR 60.113 (a)(2)

The geologic repository shall be located so that pre-waste-emplacement ground water travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment shall be at least 1,000 years or such other travel time as may be approved or specified by the Commission.

Regulations 40 CFR 191.13(a) and 10 CFR 60.113(a)(2) are associated with the movement of ground water in the immediate vicinity of the proposed repository. Regulations 40 CFR 191.16(b), 10 CFR 60.113(a)(1)(ii)(A), and 10 CFR 60.113(a)(1)(ii)(B) are associated with the existence of ground water around the repository; in particular, 10 CFR 60.113(a)(1)(ii)(A) and 10 CFR 60.113(a)(1)(ii)(B) directly depend on the emplacement environment, because ground-water moisture is presumed to be the primary mechanism for waste package degradation and for releases from the EBS.

Although 40 CFR 191 has been vacated by judicial action, performance allocation in the SCP was completed on the basis of the current U.S. Environmental Protection Agency (EPA) dose limits, and will be revised at a later date, if appropriate.

In addition to the performance requirements just identified, hydrologic information provided by the geohydrologic test programs is also required to address the favorable conditions identified in 10 CFR 60.122(b) and the potentially adverse conditions of 10 CFR 60.122(c).

An understanding and a quantitative assessment of the hydrologic conditions at Yucca Mountain are also required to address the higher level findings required by 10 CFR Part 960 for the qualifying conditions on the postclosure system guideline and the disqualifying and qualifying conditions on the technical guidelines for geohydrology, geochemistry, climatic changes, and human interference.

Three investigations are identified for the geohydrology program:

8.3.1.2.1 (Description of the regional hydrologic system); 8.3.1.2.2 (Description of the unsaturated-zone hydrologic system at the site); and 8.3.1.2.3 (Description of the saturated-zone hydrologic system at the site) These investigations will develop an understanding of the present and expected geohydrologic characteristics of each of the saturated and unsaturated flow regimes, and of the gaseous and water-vapor flow process.

The regional hydrologic flow system surrounding Yucca Mountain (Investigation 8.3.1.2.1) must be understood to define the following: 1) the boundary conditions (present and expected) for the site unsaturated and saturated zone ground-water models (Information Needs 1.1.4 (Section 8.3.5.13.4), 1.6.2 (Section 8.3.5.12.2), and Investigations 8.3.1.2.2 and 8.3.1.2.3), and 2) the hydrogeologic setting in which the site occurs.

The hydrogeologic conditions and processes of the unsaturated and saturated zone must be understood to develop models of the current and potential future flow paths and fluxes (Investigations 8.3.1.2.2 and 8.3.1.2.3), and to calculate ground-water travel time (Information Needs 1.1.4 and 1.6.2). The hydrologic characteristics to be obtained in the studies of Investigations 8.3.1.2.2 and 8.3.1.2.3 will be complemented by the data from studies of water chemistry (Investigation 8.3.1.3.1), geologic stratigraphy and structure (Investigation 8.3.1.4.1), and paleohydrology (Investigation 8.3.1.5.2).

8.3.1.2.1 Investigation: Studies to provide a description of the regional hydrologic system

Purpose and objectives of the investigation

The objective of this investigation is to develop a conceptual model of the regional hydrologic system to assist in assessing the site's suitability to contain and isolate waste. A consistent regional model of ground-water flow will be constructed, so that reliable boundary conditions can be assigned to the more critical site area embedded within the regional model. To do so, fluxes and hydraulic heads at boundaries of the regional system are required, as well as regional transmissivities. Sensitivity analyses pertaining to these variables are needed to prioritize additional data collection.

8.3.1.2.1.1 Study: Characterization of the meteorology for regional hydrology

The objectives of this study are 1) to characterize the area surrounding Yucca Mountain in terms of precipitation and its relationship to surface runoff, with particular emphasis on the Fortymile Wash drainage basin, and 2) to provide input into the rainfall-runoff model development effort. One activity is planned to collect the data required to satisfy these objectives.

8.3.1.2.1.1.1 Activity: Precipitation and meteorological monitoring

Objectives

The objective of this study is to provide site-specific information on storm precipitation at, and near, the network streamflow-measurement sites.

8.3.1.2.1.2 Study: Characterization of runoff and streamflow

The objectives of this study are to 1) collect basic data on surface-water runoff at, and peripherally to, Yucca Mountain and its hydrologic flow system; 2) use the streamflow data to describe the runoff characteristics of the area and assess the response of runoff to precipitation; 3) assess the potential for flood hazards and related fluvial-debris hazards to the YMP; and 4) provide basic data and interpretations of surface-water runoff to investigations that evaluate the amounts and processes of ground-water recharge at Yucca Mountain and surrounding areas.

8.3.1.2.1.2.1 Activity: Surface-water runoff monitoring

Objectives

The objectives of this activity are as follows:

1. To develop needed basic data on the characteristics, magnitudes, frequencies, and timing of surface-water runoff to develop an understanding of the relationships between specific runoff events and the characteristics of the storms and associated precipitation.

2. To develop a streamflow data base adequate to provide the necessary calibration data for precipitation-runoff modeling efforts for the regional study area.

8.3.1.2.1.2.2 Activity: Transport of debris by severe runoff

Objectives

The objective of this activity is to document, both quantitatively and qualitatively, the characteristics of debris transported by intense surface runoff.

8.3.1.2.1.3 Study: Characterization of the regional ground-water flow system

The objectives of this study are 1) to further define the distribution of hydraulic properties of the regional ground-water flow system, and 2) to use hydrologic, hydrochemical, and heat-flow data to determine the magnitude and direction of ground-water flow.

8.3.1.2.1.3.1 Activity: Assessment of the regional hydrogeologic data needs in the saturated zone

Objectives

The objective of this activity is to prioritize data needs for use in the regional ground-water flow description.

8.3.1.2.1.3.2 Activity: Regional potentiometric-level distribution and hydrogeologic framework studies

Objectives

The objectives of this activity are 1) to determine the potentiometric distribution within the regional ground-water flow system, and 2) to characterize the hydrogeologic framework of the regional ground-water flow system to support reliable estimates of ground-water flow direction and magnitude within the saturated zone.

8.3.1.2.1.3.3 Activity: Fortymile Wash recharge study

Objectives

The objective of this activity is to determine to what extent (quantitatively, if feasible) that Fortymile Wash has been a source of recharge to the saturated zone under present and past conditions.

8.3.1.2.1.3.4 Activity: Evapotranspiration studies

Objectives

The objective of this activity is to improve estimates of ground-water discharge by evapotranspiration in the Amargosa Desert, in order to provide boundary-condition data for regional ground-water flow models.

8.3.1.2.1.4 Study: Regional hydrologic system synthesis and modeling

The objectives of this study are 1) to synthesize the available data into a model and make a qualitative analysis of how the system is functioning and, 2) to represent quantitative observations of hydrogeologic data pertaining to the ground-water flow system in a comprehensive numerical model of ground-water flow.

8.3.1.2.1.4.1 Activity: Conceptualization of regional hydrologic flow models

Objectives

The objectives of this activity are to synthesize available data into a conceptual model that incorporates alternative hypotheses and/or existing hypotheses, and to make a qualitative analysis of how the regional and subregional ground-water flow systems function.

The primary result of this activity will be a complete, concise, qualitative description of the regional saturated-zone ground-water flow system, given the limitations of the data incorporated into the conceptual model.

8.3.1.2.1.4.2 Activity: Subregional two-dimensional areal hydrologic modeling

Objectives

The objective of this activity is to improve estimates of regional ground-water flow, by updating an existing two-dimensional, subregional, parameter-estimation model through the incorporation of additional hydrogeologic data.

8.3.1.2.1.4.3 Activity: Subregional two-dimensional cross-sectional hydrologic modeling

Objectives

The objective of this activity is to estimate the ground-water flow direction and magnitude along a potential flow path through the repository block to the accessible environment, and extending into the region, to help test the assumption of horizontal flow.

8.3.1.2.1.4.4 Activity: Regional three-dimensional hydrologic modeling

Objectives

The objective of this activity is to construct a three-dimensional model of the regional ground-water flow system of Yucca Mountain and vicinity.

Subordinate objectives of the activity are:

1. to evaluate alternative hypotheses of how the ground-water flow system functions;

2. to provide a synthesis of the hydrogeological framework and boundary conditions for site models;

3. to improve estimates of the direction and magnitude of regional ground-water flow and estimates of the hydraulic properties of geologic materials using a numerical model; and

4. to perform sensitivity analyses for the purpose of identifying key ground-water flow-system parameters, for the purpose of directing future data-collection activities.

The three-dimensional hydrologic model will also be used, as part of other studies, for predictive simulations that will be used to evaluate the response of the ground-water flow system to changes in climate, human interference, and tectonic deformation.

8.3.1.2.2 Investigation: Studies to provide a description of the unsaturated zone hydrologic system at the site

Purpose and objectives of the investigation

The objective of this investigation is to develop a model of the unsaturated-zone hydrologic system at Yucca Mountain that will assist in assessing the suitability of the site to contain and isolate waste.

8.3.1.2.2.1 Study: Characterization of unsaturated-zone infiltration

The objectives of the unsaturated-zone infiltration study are 1) to determine the effective hydraulic conductivity, storage properties, and transport properties as functions of moisture content or potential, and 2) to determine the present and estimate the future spatial distribution of infiltration rate over the repository block.

8.3.1.2.2.1.1 Activity: Characterization of hydrologic properties of surficial materials

Objectives

The objective of this activity is to characterize the infiltration-related hydrologic properties and conditions of the surficial soils and rocks covering Yucca Mountain.

8.3.1.2.2.1.2 **Activity: Evaluation of natural infiltration**

Objectives

The objective of this activity is to characterize present-day infiltration processes and net-infiltration rates in the surficial soils and rocks covering Yucca Mountain.

8.3.1.2.2.1.3 Activity: Evaluation of artificial infiltration

Objectives

The objectives of this activity are

1. To characterize the range and spatial variability of infiltration rates in approximately the upper foot of unconsolidated surficial material using double-ring infiltrometer studies.

2. To characterize the range and spatial variability of infiltration rates, flow velocities, and flow pathways in approximately the upper 15 ft of both consolidated and unconsolidated surficial materials using ponding studies.

3. To characterize the complex relationship between rainfall, thickness of soil, and development of perched water tables (WTs) in approximately the upper 3 ft of unconsolidated surficial material using small-plot rainfall simulation tests.

4. To characterize the relationship between precipitation, runoff, infiltration, and evaporation, in approximately the upper 15 ft, on at least one site, in each hydrogeologic surficial unit using large-plot rainfall simulation tests.

8.3.1.2.2.2 Study: Water movement test

The objective of this study is to obtain information from isotopic measurements of soil, tuff, and water samples collected from Yucca Mountain that is pertinent for assessing the performance of a nuclear waste repository.

8.3.1.2.2.2.1 Activity: Chloride and chlorine-36 measurements of percolation at Yucca Mountain

Objectives

The purpose of this activity is to help quantify the amount of percolation from precipitation into the unsaturated zone at Yucca Mountain. The data will be used as part of the input to characterize the movement of water through the unsaturated zone at Yucca Mountain.

8.3.1.2.2.3 Study: Characterization of percolation in the unsaturated zone--surface-based study

The objectives of the surface-based unsaturated zone percolation study are to 1) determine the present in situ hydrologic properties of the unsaturated zone hydrogeologic units and structural features, 2) determine the present vertical and lateral variation of percolation flux through the hydrogeologic units and structural features, 3) investigate the relationships between present flux and past climatic conditions, and 4) determine the effective hydraulic conductivity, storage properties, and transport properties as functions of moisture content or potential.

8.3.1.2.2.3.1 Activity: Matrix hydrologic properties testing

Objectives

The objectives of this activity are

1. To characterize the flux-related, matrix hydrologic properties of major unsaturated-zone hydrogeologic units through laboratory testing of geologic samples obtained from surface based boreholes and excavations and from coreholes in the ESF.

2. To use statistical and geostatistical methods to calculate, with known certainties, the values of flux-related matrix hydrologic properties within large volumes of rock beneath Yucca Mountain.

8.3.1.2.2.3.2 Activity: Site vertical borehole studies

Objectives

The objectives of this activity are

1. To define the potential field.

2. To determine the in situ bulk permeability characteristics of the unsaturated media within the proposed repository host rock and surrounding units at Yucca Mountain, Nevada.

8.3.1.2.2.3.3 Activity: Solitario Canyon horizontal borehole study

Objectives

The objectives of this activity are

1. To examine, on a local and limited scale, the extent of fracturing, brecciation, and gouge development associated with the Solitario Canyon fault.

2. To evaluate, locally, the hydrogeologic significance of fault-related features on water movement within the Solitario Canyon fault zone.

3. To evaluate, based on the findings developed under the first two objectives, whether additional information is needed to characterize adequately hydrologic boundary conditions along the Solitario Canyon fault zone, should the results indicate potentially adverse effects on repository performance.

8.3.1.2.2.4 Study: Characterization of Yucca Mountain percolation in the unsaturated zone--Exploratory Studies Facility study

This study consists of hydrologic tests that will be conducted in the ESF. The ultimate purposes of the ESF hydrologic tests are to 1) supplement and complement the surface-based hydrologic information needed to characterize the Yucca Mountain site, and 2) provide information for analyzing fluid flow and the potential for radionuclide transport through unsaturated tuff. The integrated results from the ESF hydrologic tests will be combined with data from the surface-based studies to provide an overall understanding of the unsaturated-zone hydrologic system.

8.3.1.2.2.4.1 Activity: Intact-fracture test in the Exploratory Studies Facility

Objectives

The objective of this activity is to evaluate fluid-flow and chemical-transport properties of single, relatively undisturbed fractures.

8.3.1.2.2.4.2 Activity: Percolation tests in the Exploratory Studies Facility

Objectives

The objectives of this activity are to determine the hydrologic conditions that control the occurrence of fluid flow within fractures and matrix and to provide experimental data against which the validity of numerical and conceptual models can be tested.

8.3.1.2.2.4.3 Activity: Bulk-permeability test in the Exploratory Studies Facility

Objectives

The objectives of this activity are

1. To determine the scale at which the host rock behaves as an equivalent anisotropic porous medium.

2. To compare hydraulic test results against a distribution of simulated results calculated from a large number of realizations of the possible fracture networks conditioned on average fracture orientation and/or fracture density data.

3. To use a numerical fracture-flow model to establish the minimum dimensions at which other rock masses with the same fracture characteristics behave as equivalent porous media and to examine the dependence of rock-mass dimensions on changing saturation.

8.3.1.2.2.4.4 Activity: Radial borehole tests in the Exploratory Studies Facility

Objectives

The objectives of this activity are to

1. Detect vertical movement of water in both the vapor and liquid forms and to evaluate the potential for lateral movement of water along the hydrogeologic contacts.

2. Evaluate the radial extent of excavation effects on the hydrologic properties of unsaturated hydrogeologic units.

8.3.1.2.2.4.5 Activity: Excavation effects test in the Exploratory Studies Facility

Objectives

This activity will monitor changes to both the stress state and fractured rock permeability caused by excavating. The objective is to use these data, as well as other physical properties gathered during the activity, to validate and calibrate a coupled hydraulic-mechanical finite-element model. The model will be used to predict stress and ensuing permeability changes around excavation openings.

8.3.1.2.2.4.6 Activity: Calico Hills testing in the Exploratory Studies Facility

This activity intentionally deleted; testing in the Calico Hills (CH) will be described in revisions to ESF Study Plans.

8.3.1.2.2.4.7 Activity: Perched-water test in the Exploratory Studies Facility

Objectives

The objectives of this activity are to 1) detect the occurrence of any perched-water zones, 2) estimate the hydraulic properties of the zones, and 3) determine the implication of the existence of such zones on flux, flow paths, and travel times.

8.3.1.2.2.4.8 Activity: Hydrochemistry tests in the Exploratory Studies Facility

Objectives

The objectives of this activity are to

1. Understand the gas transport processes within the unsaturated zone and to provide independent evidence of flow direction, flux, and travel time of gas.

2. Design and implement methods for extracting uncontaminated pore fluid from rock excavated during ramp construction.

3. Determine the flow direction, flux, and travel time of water in the unsaturated zone by isotope geochemistry techniques.

4. Determine the extent of the water-rock interaction so that geochemical modeling can be performed to deduce the flow path and to understand the geochemical evolution of the unsaturated zone water.

8.3.1.2.2.4.9 Activity: Multipurpose-borehole testing

Objectives

The planned objectives of this activity are

1. To monitor and evaluate potential hydrologic and engineering interference effects from ramp construction on ESF tests and interference effects between ESF tests.

2. To identify possible occurrence of perched water and, if present, sample and test.

3. To confirm engineering and hydrogeologic properties on which the ESF design is based and identify anomalous conditions in the vicinity of the ESF.

8.3.1.2.2.4.10 Activity: Hydrologic properties of major faults encountered in main test level (MTL) of the Exploratory Studies Facility

Objective

The objective of this activity is to investigate the permeability and flow conditions of the major faults encountered in the ramps and in drifts at both the CH and Topopah Spring (TS) levels of the ESF.

8.3.1.2.2.5 Study: Diffusion tests in the Exploratory Studies Facility

8.3.1.2.2.5.1 Activity: Diffusion tests in the Exploratory Studies Facility

Objectives

The objective of this activity is to determine in situ the extent to which nonsorbing tracers diffuse into the water-filled pores of the tuffs of the TS welded unit at the MTL of the ESF. A diffusion test is also proposed in the CH unit.

8.3.1.2.2.6 Study: Characterization of gaseous-phase movement in the unsaturated zone

The objectives of this study are 1) to describe the pre-waste emplacement gas-flow field, 2) to identify structural controls on fluid flow, 3) to determine conductive and dispersive properties of the unsaturated zone for gas flow, and 4) to model the transport of water and tracers in the gas phase.

8.3.1.2.2.6.1 Activity: Gaseous-phase circulation study

Objectives

The objectives of this activity are

1. To describe and model the pre-waste-emplacement gas-flow field and its effect on net water-vapor transport from the unsaturated zone by modeling the western portions of Yucca Mountain as a two-dimensional and/or three-dimensional boundary problem in compressible nonisothermal flow.

2. To provide the parameters necessary for modeling gas flow from and to the repository and the potential transport of radionuclides as well as the gaseous flux of moisture affecting deep percolation after the repository is in place.

3. To reconstruct the air circulation history at instrumented boreholes from the time of drilling until stemmed and instrumented in order to estimate the time required for poststemming recovery of ambient gas and moisture conditions as an aid in interpreting gas composition and thermocouple psychrometer data.

4. To determine, by flow and pressure measurements in single holes, and by cross-hole interference tests, the near-field air conductivities, storativity, and anisotropy of the unit above the repository horizon.

5. To determine effective porosities and dispersivities of the fracture system by the interpretation of natural and artificial gas tracer data as an aid in the modeling described in items 1 and 2.

8.3.1.2.2.7 Study: Hydrochemical characterization of the unsaturated zone

The objectives of this study are to 1) understand the gas transport mechanism, direction, flux and travel time within the unsaturated zone; 2) design and implement methods for extracting pore fluids from the tuff; 3) provide independent evidence of flow direction, flux, and travel time of water in the unsaturated zone; 4) determine the extent of the water-rock interaction, and 5) model geochemical evolution of ground water in the unsaturated zone.

8.3.1.2.2.7.1 Activity: Gaseous-phase chemical investigations

Objectives

The objective of this activity is to understand the gas transport mechanism, and provide evidence of gas flow direction, flux, and travel time within the unsaturated zone.

8.3.1.2.2.7.2 Activity: Aqueous-phase chemical investigations

Objectives

The objectives of this activity are

1. To design and implement methods for extracting pore fluids from unsaturated zone tuff units.
2. To provide evidence of flow direction, flux, and travel time of water in the unsaturated zone.
3. To determine the extent of the water-rock interaction and to model geochemical evolution of ground water in the unsaturated zone.

8.3.1.2.2.8 Study: Fluid flow in unsaturated, fractured rock

The objective of this study is to develop and refine conceptual and numerical models describing both gas flow as well as liquid water and solute movement in unsaturated, fractured rock.

8.3.1.2.2.8.1 Activity: Development of conceptual and numerical models of fluid flow in unsaturated, fractured rock

Objectives

The objective of this activity is to develop detailed conceptual and numerical models of fluid flow and transport within unsaturated, fractured rock at Yucca Mountain.

8.3.1.2.2.8.2 Activity: Validation of conceptual and numerical models of fluid flow through unsaturated, fractured rock

Objectives

The objective of this activity is to evaluate the reasonableness of the concepts on which the models developed under Activity 8.3.1.2.2.8.1 are based, by using the results of laboratory tests and tests performed in the ESF to access the adequacy of model performance.

8.3.1.2.2.9 Study: Site unsaturated-zone modeling and synthesis

The purpose and activities of this study are to 1) develop appropriate conceptual models for the site unsaturated-zone hydrogeologic system; 2) select, modify, or develop numerical hydrologic models capable of simulating the hydrogeologic system and its component subsystems; 3) apply the models to predict the system response to changing external and internal conditions; 4) evaluate the accuracy of the models using stochastic modeling, conventional statistical analyses, and sensitivity analyses; and 5) integrate data and analyses to synthesize a comprehensive qualitative and quantitative description of the site unsaturated-zone hydrogeologic system under present as well as probable, or possible, future conditions.

8.3.1.2.2.9.1 Activity: Conceptualization of the unsaturated-zone hydrogeologic system

Objectives

The objectives of this activity are to: 1) develop conceptual models for the overall moisture flow system within the unsaturated zone at Yucca Mountain, and develop an internally consistent set of hypotheses that describe those aspects of the site hydrogeologic system that are needed to assess the capability of the site to isolate nuclear waste for a period of 10,000 yr or longer.

8.3.1.2.2.9.2 Activity: Selection, development, and testing of hydrologic-modeling computer codes

Objectives

The objectives of this activity are twofold: 1) to select, evaluate, and adapt existing numerical hydrologic-modeling codes for application to the site unsaturated-zone hydrogeologic system, and 2) to modify existing codes or develop new codes, as needed, to simulate particular problems or aspects that are unique to the Yucca Mountain system.

8.3.1.2.2.9.3 Activity: Simulation of the natural hydrogeologic system

Objectives

The objectives of this activity are to construct appropriate hydrologic models for the natural site hydrogeologic system to 1) simulate and investigate the present existing state of the system, and 2) predict probable future and past states of the system under changes in the environmental conditions.

8.3.1.2.2.9.4 Activity: Stochastic modeling and uncertainty analysis

Objectives

The objective of this activity is to assess the probable limits of uncertainty of numerical-model predictions caused by uncertainties in the material-property and boundary-condition data.

8.3.1.2.2.9.5 Activity: Site unsaturated-zone integration and synthesis

Objective

The objective of this activity is to integrate all applicable site data and analyses in order to synthesize a continually updated, comprehensive representation for the site unsaturated-zone hydrogeologic system.

8.3.1.2.3 Investigation: Studies to provide a description of the saturated zone hydrologic system at the site

Purpose and objectives of the investigation

The objective of this investigation is to develop a model of the saturated-zone hydrologic system of Yucca Mountain, which will assist in assessing the suitability of the site to contain and isolate waste.

8.3.1.2.3.1 Study: Characterization of the site saturated-zone ground-water flow system

The objectives of this study are 1) to determine the internal and external boundary conditions that can be applied to the site saturated zone model, and 2) to determine the ground-water flow magnitudes and directions at the site.

8.3.1.2.3.1.1 Activity: Solitario Canyon fault study in the saturated zone

Objectives

The objective of this activity is to determine the hydrogeologic nature of the Solitario Canyon fault and if it is a barrier to eastward movement of ground water through the repository block.

8.3.1.2.3.1.2 Activity: Site potentiometric-level evaluation

Objectives

The objectives of this study are to

1. Refine time and configuration of the spatial dependence of the potentiometric surface.

2. Measure water-level variations with time in existing borehole and calculate average levels, as input data for hydraulic gradient calculations.

3. Analyze the character and magnitudes of water-level fluctuations to determine their causes, and, if possible, to estimate formation elastic and fluid-flow properties.

8.3.1.2.3.1.3 Activity: Analysis of single- and multiple-well hydraulic-stress tests

Objectives

The objectives of this activity are to

1. Determine intraborehole flow profiles for each of the C-holes during static conditions and while pumping.

2. Correlate lithology, fractures, and intraborehole flow rates.

3. Characterize the type of flow (linear, radial, spherical, fracture, porous) that is occurring between boreholes.

4. Determine the causes of the apparent deviant pressure transients observed in slug tests in UE-25c#1.

5. Identify the nature of significant hydraulic boundaries present at the scale of the tests. This information will be especially important in designing multiple-well interference tests and tracer tests at the C-holes.

6. Determine bulk estimates of aquifer properties: transmissivity, storage coefficient, specific storage, and effective hydraulic porosity.

7. Determine to what extent the ground-water system responds to hydraulic stress as confined or unconfined.

8.3.1.2.3.1.4 Activity: Multiple-well interference testing

Objectives

The objectives of this activity are to

1. Determine hydraulic properties, including hydraulic conductivity and storage coefficient, needed for quantitative evaluation of groundwater flow.

2. Determine if the fractured media of Yucca Mountain can be represented as an anisotropic porous media at the scale of multiple-well tests or if a fracture-network model is more appropriate.

3. Evaluate the relation between hydraulic properties determined by single well tests and those determined by multiple-well tests.

8.3.1.2.3.1.5 Activity: Testing of the C-hole sites with conservative tracers

Objectives

The objectives of this activity are to

1. Determine the following properties by single-well and multiple-well tests at the C-holes: 1) effective porosity, 2) longitudinal dispersivity, 3) regional pore-water velocity, and 4) possibly matrix diffusion.

2. Evaluate the relation between aquifer properties estimated by porous-media techniques and fracture characteristics used in fracture-network modeling.

8.3.1.2.3.1.6 Activity: Well testing with conservative tracers throughout the site

Objectives

The objective of this activity is to determine the following properties at the Yucca Mountain site: 1) effective porosity, 2) longitudinal dispersivity, and 3) regional pore-water velocity.

8.3.1.2.3.1.7 Activity: Testing of the C-hole sites with reactive tracers

Objectives

The objective of this activity is to characterize the chemical and physical properties of the geologic media in the saturated zone in the vicinity of the C-holes that will affect radionuclide retardation during ground-water flow within the saturated zone.

8.3.1.2.3.1.8 Activity: Well testing with reactive tracers throughout the site

Objectives

The objective of this activity is to characterize the chemical and physical properties of the geologic media in the saturated zone throughout the site that will affect radionuclide retardation during ground-water flow within the saturated zone.

8.3.1.2.3.2 Study: Characterization of the saturated-zone hydrochemistry

The objectives of this study are to 1) describe the chemical composition of, and spatial compositional variations in, saturated-zone ground waters using new and extant data; 2) identify the chemical and physical processes that influence ground-water chemistry; and 3) aid in the identification and quantification of fluxes to, from, and within the saturated zone.

8.3.1.2.3.2.1 Activity: Assessment of saturated-zone hydrochemical data availability and needs

Objectives

The objectives of this activity are to

1. Compile and evaluate extant hydrochemical data for the saturated zone at the site and regional scales, and

2. Identify data deficiencies and potential sampling sites and assemble requisite material for sample and field data collection, and

3. Augment extant information by collecting and analyzing new hydrochemical samples and data.

8.3.1.2.3.2.2 Activity: Hydrochemical characterization of water in the upper part of the saturated-zone

Objectives

The objectives of this activity are

1. To describe the hydrochemistry of the upper part of the saturated- zone by collecting representative water samples from intervals within the upper 100 m of the saturated zone, within and adjacent to the site area, and studying their chemical and isotopic compositions.

2. To estimate flux to or from the saturated-zone by collecting interstitial water and gas samples from immediately above the WT and studying their chemical and isotopic compositions.

8.3.1.2.3.2.3 Activity: Regional hydrochemical tests and analyses

Objectives

The objective of this activity is to describe regional spatial variations in ground-water chemistry by examining extant data and in the saturated zone by collecting representative water samples from wells and springs within the region and by studying their chemical and isotopic compositions.

8.3.1.2.3.2.4 Activity: Synthesis of saturated-zone hydrochemistry

Objectives

The objectives of this activity are to

1. Describe the saturated-zone hydrochemistry.
2. Identify the chemical and physical processes that influence groundwater chemistry.
3. Relate compositional variations to water/rock interactions and the physical nature of the ground-water flow system to aid in the identification and/or quantification of ground-water travel times; climatic conditions during periods or recharge; flow paths; and fluxes to, from, and within the saturated zone.

8.3.1.2.3.3 Study: Saturated-zone hydrologic system synthesis and modeling

The objectives of this study are to 1) synthesize the available data into a model and make a qualitative analysis of how the system is functioning, and 2) represent quantitative observations of hydrogeologic data pertaining to the ground-water flow system in a comprehensive flow model.

8.3.1.2.3.3.1 Activity: Conceptualization of saturated-zone flow models within the boundaries of the accessible environment

Objectives

The data objectives of this activity are to synthesize the available hydrogeologic data to develop a conceptual model and make a qualitative analysis of how the site saturated-zone hydrogeologic system is functioning.

8.3.1.2.3.3.2 Activity: Development of fracture network model

Objectives

The objectives of this activity are to

1. Develop and evaluate methods for simulating ground-water flow and conservative solute transport in saturated fractured rock beneath Yucca Mountain.

2. Relate results of hydraulic and conservative-tracer tests in wells to fracture-network characteristics at Yucca Mountain.

3. Develop methods for identifying transmissive fracture zones in rocks penetrated by boreholes.

4. Identify geohydrologic conditions at Yucca Mountain where ground-water flow and conservative solute transport can be properly evaluated using the porous-medium assumption.

8.3.1.2.3.3.3 Activity: Calculation of flow paths, fluxes, and velocities within the saturated-zone to the accessible environment

Objectives

The objectives of this activity are to

1. Estimate ground-water flow direction and magnitude for input into travel-time calculations.

2. Evaluate the porous-media concept and fracture-network concept for determining flow paths, fluxes, and velocities.

8.3.1.3 Objectives of the geochemistry program

The specific data needs by the performance and design issues are as follows:

1. Issue 1.1 (total system performance, Section 8.3.5.13) calls for retardation factors for radionuclides in the rock units along the flow paths under expected and unexpected conditions for 10,000 to 100,000 yr. Issue 1.1 also calls for major ion water chemistry, dispersion coefficients, and matrix diffusion coefficients.

2. Issue 1.2 (individual protection, Section 8.3.5.14) calls for the same data as Issue 1.1, except only for expected conditions and only for 1,000 yr. In addition, data on gas phase transport is requested.

3. Issue 1.3 (ground-water protection, Section 8.3.5.15) again calls for the same data as Issue 1.1, except only for expected conditions and only for 1,000 yr.

4. Issue 1.5 (engineered-barrier system release rates, Section 8.3.5.10) calls for changes in geochemical conditions to serve as input to scenarios, and for radionuclide sorptive and transport properties of the host rock.

5. Issue 1.6 (ground-water travel time, Section 8.3.5.12) calls for geochemical data relevant to determining the extent of the disturbed zone, specifically, data on silica mobilization as it affects permeability.

6. Issue 1.8 (Nuclear Regulatory Commission (NRC) siting criteria, Section 8.3.5.17) calls for data on geochemical conditions and processes at the site for the evaluation of the presence or absence of the favorable and potentially adverse conditions and analysis of geochemical effects on subsystem/system performance.

7. Issue 1.9a (higher level findings--postclosure system and technical guidelines, Section 8.3.5.18) calls for geochemical data for making the higher level finding on the technical guideline on geochemistry.

8. Issue 1.10 (waste package characteristics--postclosure, Section 8.3.4.2) requests data on the vadose zone water chemistry to support the waste package design and testing programs.

9. Issue 1.11 (configuration of underground facilities--postclosure, Section 8.3.2.2) requests data on mineral stability to support testing to determine the stability of mined openings and the thermal response of the host rock.

10. Issue 1.12 (seal characteristics, Section 8.3.2.2) requests data on the vadose zone water chemistry to support the testing of ground water-seals materials interactions.

8.3.1.3.1 Investigation: Studies to provide information on water chemistry within the potential emplacement horizon and along potential flow paths

Purpose and objectives of the investigation

The goal of this investigation is to provide a ground-water chemistry model that would 1) explain the present ground-water composition as a result of interactions of the ground water with minerals, 2) be able to predict future variations in ground-water chemistry under anticipated and unanticipated conditions that would alter radionuclide flux through the saturated and unsaturated zone, and 3) support and be integrated with other modeling efforts within the geochemistry program.

8.3.1.3.1.1 Study: Ground-water chemistry model

Objectives

The goal of this study is to develop a ground-water chemistry model that will initially describe pre-emplacement conditions. Future changes in these properties and processes will then be considered, including changes in infiltration as influenced by climatic conditions; long-term mineralogic changes,

particularly those influenced by the thermal pulse from emplaced waste; and changes in the material properties due to the emplaced waste, or possible igneous activity.

8.3.1.3.2 Investigation: Studies to provide information on mineralogy, petrology, and rock chemistry within the potential emplacement horizon and along potential flow paths

Purpose and objectives of the investigation

This investigation will provide the baseline set of data and understanding of the natural environment in which geochemical and other processes interact.

8.3.1.3.2.1 Study: Mineralogy, petrology, and chemistry of transport pathways

The goals of this study are 1) to determine the three-dimensional distribution of mineral types, compositions, abundances, and petrographic textures within the potential host rock, and 2) to determine the three-dimensional distribution of mineral types, composition, and abundances in rocks beyond the host rock that provide pathways to the accessible environment.

8.3.1.3.2.1.1 Activity: Petrologic stratigraphy of the Topopah Spring Member

Objectives

The goal of this activity is to determine the petrologic variability within the devitrified Topopah Spring Member (PTn) at Yucca Mountain and to define the stratigraphic distribution of variability.

8.3.1.3.2.1.2 Activity: Mineral distributions between the host rock and the accessible environment

Objectives

Using the data provided as site characterization progresses, this activity will attempt to determine the three-dimensional distribution chemistry and the total abundance of all major rock-matrix minerals, between the host rock and the accessible environment.

8.3.1.3.2.1.3 Activity: Fracture mineralogy

Objectives

The objective of this activity is to determine the distributions of minerals within fractures at Yucca Mountain, within all significant rock masses that might provide transport pathways with some component of fracture flow.

8.3.1.3.2.2 Study: History of mineralogic and geochemical alteration of Yucca Mountain

The goals of this study are 1) to determine the timing, temperatures, and hydrologic conditions of past alteration at Yucca Mountain, and 2) to study experimentally the dehydration of smectite, zeolite, and glass.

8.3.1.3.2.2.1 Activity: History of mineralogic and geochemical alteration of Yucca Mountain

Objectives

The goals of this activity are 1) constrain the timing of deep-seated alteration of a hydrothermal and epigenetic nature, 2) estimate the long-term thermal stabilities of important sorptive phases, such as clinoptilolite, and of the silica polymorphs that can influence water composition, precipitation, and the stabilities of other silicate minerals.

8.3.1.3.2.2.2 Activity: Smectite, zeolite, manganese minerals, glass dehydration, and transformation

Objectives

The goal of this activity is to determine how minerals and glasses important in the rocks at Yucca Mountain will dehydrate and transform under anticipated thermal loads and to investigate the ability of zeolites and smectites to rehydrate after the peak in temperature.

8.3.1.3.3 Investigation: Studies to provide information required on stability of minerals and glasses

Purpose and objectives of the investigation

The goal of this investigation is to determine the stability of minerals and glasses along the flow paths to the accessible environment in order to assess impacts of waste emplacement on mineral stability and the resulting effect on radionuclide retardation.

8.3.1.3.3.1 Study: Natural analog of hydrothermal systems in tuff

Objectives

The goals of this study are 1) to improve the reliability of long-term predictions regarding hydrothermal rock alteration in devitrified welded ash-flow tuff, 2) test the capabilities of the EQ3/6 geochemical code (Section 7.4.4) through modeling of alteration mineral assemblages in natural systems, and 3) to provide a better understanding of the origin of alteration mineral assemblages found in Yucca Mountain at present. This study will also help in development of the conceptual model for mineral evolution in Yucca Mountain and will aid substantially in guiding the laboratory studies. This

study will investigate the origin and evolution of secondary mineral assemblages produced in active hydrothermal systems in rock types similar to those which compose Yucca Mountain.

8.3.1.3.3.2 Study: Kinetics and thermodynamics of mineral evolution

The goals of this study are 1) to investigate the kinetics of glass and silica polymorph transitions and their relationship to aqueous silica activity, and 2) to provide thermodynamic data for clinoptilolite/heulandite and albite and analcime.

8.3.1.3.3.2.1 Activity: Kinetic studies of zeolite and related framework silicates

Objectives

The goal of this activity is to predict the rates of possible transformation of silica polymorphs in Yucca Mountain and the effect such transformations would have on aqueous silica activity. This information will be combined with information from other activities and studies, particularly Activities 8.3.1.3.3.2.2 and 8.3.1.3.3.2.3 and Study 8.3.1.3.2.1 to assess the effects of silica polymorph evolution on the stability of other minerals, particularly clinoptilolite, in Yucca Mountain.

8.3.1.3.3.2.2 Activity: Determination of end-member free energies for clinoptilolite-heulandite, albite, and analcime

Objectives

The goal of this activity is to determine end-member free energies from solubility measurements. This activity will provide enthalpy of formation data which will then be used to determine the thermodynamic stability of these silicates.

8.3.1.3.3.2.3 Activity: Solid solution descriptions of clinoptilolite-heulandite and analcime

Objectives

The goal of this activity is to provide descriptions of the thermodynamics of the clinoptilolite-heulandite and analcime solid solutions in support of the development of the mineral stability model. The thermodynamic descriptions developed will be tied to the thermodynamics of discrete compositions of clinoptilolite and analcime determined in Activity 8.3.1.3.3.2.2 but will extend the thermodynamic description to the entire range of possible compositions.

8.3.1.3.3.3 Study: Conceptual model of mineral evolution

Objectives

A conceptual model will be produced to explain the observed distributions of minerals in Yucca Mountain. Emphasis will be placed on the evolution of framework silicates (feldspars, zeolites, and silica polymorphs). The model will address the general chemical evolution of vitric tuffs. This model will also be used to predict future mineral evolution in the mountain due to both natural processes and as a result of a repository emplacement.

8.3.1.3.4 Investigation: Studies to provide the information required on radionuclide retardation by sorption processes along flow paths to the accessible environment

Purpose and objectives of the investigation

The purpose of this investigation is to obtain data on the sorption behavior of key radionuclides as required by Issue 1.1 (Section 8.3.5.13). Specifically, Issue 1.1 requires that, for each key radionuclide species known to be chemically sorbing and for each rock unit in the controlled area except for the overburden, estimates should be provided of the mean and standard deviation of the distribution coefficients $K_d(i)$, under the range of water-rock chemical conditions expected for the unit in question. The key radionuclides identified by Issue 1.1 are isotopes of americium, carbon, cesium, curium, iodine, neptunium, plutonium, strontium, technetium, uranium, and zirconium.

The objectives of this investigation are 1) to obtain laboratory batch sorption coefficients for the key radionuclides as a function of the parameters listed above, to statistically evaluate these coefficients, and to develop an understanding of sorption mechanisms for each of the key radionuclides; 2) to evaluate the significance of biological sorption and transport; and 3) to develop a capability for the prediction of the sorption behavior of key radionuclides under conditions not assessed in the experimental program.

8.3.1.3.4.1 Study: Batch sorption studies

The goal of the batch sorption experiments is 1) to obtain sorption coefficients for key radionuclides discussed in the individual studies below, 2) to use statistical analysis to evaluate the experimental results (Activity 8.3.1.3.4.1.5) and 3) to provide the data base for the development of models to allow prediction of sorption coefficients under conditions not directly addressed by the experimental program. The values for sorption coefficients obtained in this study will be used to interpret the results obtained in crushed-tuff column experiments (Activity 8.3.1.3.6.1.1).

8.3.1.3.4.1.1 Activity: Batch sorption measurements as a function of solid phase composition

Objectives

The purpose of this activity is to determine sorption coefficients for radionuclides on tuffs of the CH zeolitic and vitric units, on devitrified tuffs, and on pure minerals representative of the minerals present in the rock and fractures of the repository block. Further insight into sorption mechanisms and sorption kinetics will be provided by comparison of these results with the results of crushed-rock column experiments (Activity 8.3.1.3.6.1.1). The experimental emphasis will be on the elements americium, plutonium, neptuniun, uranium, and technetium.

8.3.1.3.4.1.2 Activity: Sorption as a function of sorbing element concentrations (isotherms)

Objectives

The purpose of this activity is 1) to characterize the dependence of sorption coefficients upon the concentration of the element being sorbed by developing isotherms for the radionuclide, 2) to compare the measured values of K_d with the requirements of Issue 1.1 as they are developed, 3) to develop isotherms for the radionuclides to be tested, and 4) to incorporate the isotherm data into the sorption data base.

8.3.1.3.4.1.3 Activity: Sorption as a function of ground-water composition

Objectives

The goal of this activity is 1) to measure sorption coefficients as a function of ground-water compositions anticipated along potential travel paths, and 2) to determine if the values of K_d are above the goals set by Issue 1.1 (Section 8.3.5.13) as they are developed.

8.3.1.3.4.1.4 Activity: Sorption on particulates and colloids

Objectives

The goal of this activity is to determine if sorption of important radionuclides occurs on particulates or colloids that may be present in ground waters along potential transport pathways. Results of experiments on transport of radiocolloids and particulates will direct the scope of batch experiments performed in this activity.

8.3.1.3.4.1.5 Activity: Statistical analysis of sorption data

Objectives

The objectives of this activity are to 1) determine those variables (e.g., mineralogy, ground-water composition, and atmosphere) having the most profound effect on the sorption coefficients; 2) predict sorption coefficients as a function of mineralogy and, perhaps, ground-water composition; 3) estimate errors associated with predicted sorption coefficients; and 4) identify gaps in the experimental data.

8.3.1.3.4.2 Study: Biological sorption and transport

Objectives

The objectives of this study are 1) to determine what effects microorganisms have on the movement of radioactive waste (i.e, effects on sorption), 2) to determine if microbial activities play a role significant enough to be included in a performance calculation for Yucca Mountain, 3) to identify the quantity, location, and characteristics of past and future organic materials used at the site and their susceptibility to microbiological degradation, and 4) to determine the effect that these microorganisms will have on the movement of actinides through analysis of their effect on ground-water quality, colloid formation, effect on solubility, or by direct sorption of the actinides.

8.3.1.3.4.3 Study: Development of sorption models

Objectives

The objective of this study is to 1) model the sorption experiments on rocks and minerals representing the proposed repository block, and 2) to derive a capability to predict sorption coefficients for key radionuclides under water-rock conditions not included within the experimental program.

8.3.1.3.5 Investigation: Studies to provide the information required on radionuclide retardation by precipitation processes along flow paths to the accessible environment

Purpose and objectives of the investigation

The purpose of this investigation is to supply input data for calculations of radionuclide transport along potential transport pathways from the repository to the accessible environment at the Yucca Mountain site. These calculations are required to address the overall system performance objective for radionuclide release in 10 CFR 60.112 (Issue 1.1, Section 8.3.5.13) and in making findings on the postclosure system guideline and the technical guidelines for geochemistry in 10 CFR 960.4 (Issue 1.9, Section 8.3.5.18), and in the siting criteria of 10 CFR 60.122 (Issue 1.8, Section 8.3.5.17).

8.3.1.3.5.1 Study: Dissolved species concentration limits

The goal of this study is to provide solubility or concentration limits for dissolved species of important waste elements under conditions that are characteristic of the repository and along flow paths toward the accessible environment.

8.3.1.3.5.1.1 Activity: Solubility measurements

Objectives

The goal of this activity is first to specify the conditions under which solubility experiments will be carried out and then to measure solubilities or concentration limits of important waste elements under these conditions.

8.3.1.3.5.1.2 Activity: Speciation measurements

Objectives

The goal of this activity is to identify important aqueous species of waste elements under conditions described in Activity 8.3.1.3.5.1.1 and determine their formation constants.

8.3.1.3.5.1.3 Activity: Solubility modeling

Objectives

The goal of this activity is to develop the thermodynamic models and data needed to calculate waste element solubilities over the range of conditions expected at the site.

8.3.1.3.5.2 Study: Colloid behavior

The goal of this study is to determine the stability of waste element colloids under expected site-specific conditions that might be encountered at the repository or along flow paths toward the accessible environment.

8.3.1.3.5.2.1 Activity: Colloid formation characterization and stability

Objectives

The objective of this activity is to determine the formation and stability of waste element colloids.

8.3.1.3.5.2.2 Activity: Colloid modeling

Objectives

The objective of this activity is to develop models and model parameters to calculate natural colloid concentrations and stability and to describe the disposition of the waste element species as the colloids break up.

8.3.1.3.6 Investigation: Studies to provide the information required on radionuclide retardation by dispersive, diffusive, and advective transport processes along flow paths to the accessible environment

Purpose and objectives of the investigation

The goal of this investigation is to experimentally determine the rate of movement and effective retardation of radionuclides by dispersive, diffusive, and advective processes. Specifically, Issue 1.1 (Section 8.3.5.13) needs experimental evidence that could confirm or deny the theory of advective-diffusive coupling of solute concentrations in matrix and fracture flow. This theory is embodied in the transport model for fracture flow currently used in the transport model of TOSPAC (described in Issue 1.1). Issue 1.1 states that this information is crucial in establishing the credibility of transport phenomenology embodied in any models used to assess the consequences of the release scenarios associated with the water pathways.

8.3.1.3.6.1 Study: Dynamic transport column experiments

Objective

All the experiments in the dynamic transport column experiment study measure the breakthrough or elution curve for tracers through tuff columns.

8.3.1.3.6.1.1 Activity: Crushed tuff column experiments

Objective

The purpose of this activity is to measure the rate of movement of radionuclides through crushed tuff columns relative to tritiated water and other well-defined chemical species or colloids. Sorption ratios will be determined by comparing the crushed tuff column results with the batch sorption results from Investigation 8.3.1.3.4. Comparison of column and batch techniques using pure minerals will also be conducted.

8.3.1.3.6.1.2 Activity: Mass transfer kinetics

Objectives

The goal of this activity is to determine the elution rate of radionuclides as a function of water velocity for crushed tuff columns (homogeneous system), solid rock columns (heterogeneous system), and for pure mineral samples.

8.3.1.3.6.1.3 Activity: Unsaturated tuff columns

Objectives

This activity will measure the relative migration rate of radionuclides through partially unsaturated rock columns and will investigate the effects of varying rock-water ratios on the rate of migration of radionuclides.

8.3.1.3.6.1.4 Activity: Fractured tuff column studies

Objectives

The objectives of this activity are 1) to measure the transport and diffusion of radionuclides through naturally fractured tuff, and 2) to examine the movement of tracers through naturally fractured Yucca Mountain cores to test the transport models.

8.3.1.3.6.1.5 Activity: Filtration

Objectives

This study will attempt to quantify the filtration of colloids and particulates by the tuff as a function of particle or pore size using solid tuff cores and fractured cores.

8.3.1.3.6.2 **Study: Diffusion**

The objectives of this study are 1) to measure the diffusivity and kinetics of adsorption in a purely diffusive system (i.e., no advection) from the uptake of radionuclides on intact tuff as a function of time, and 2) to conduct scaling studies to determine up to what scale the matrix diffusion model can be applied with confidence.

8.3.1.3.6.2.1 Activity: Uptake of radionuclides on rock beakers in a saturated system

Objectives

This activity will measure the uptake of radionuclides by rock beakers as function of time. These results will provide a baseline for the following activities on diffusion through a saturated tuff slab and diffusion in an unsaturated tuff block.

8.3.1.3.6.2.2 Activity: Diffusion through a saturated tuff slab

Objectives

This activity is designed to measure the diffusion of radionuclides in a purely diffusive system (no advection), by varying the thickness of slabs of PTn tuff and CH zeolitic tuff.

8.3.1.3.6.2.3 Activity: Diffusion in an unsaturated tuff block

Objectives

The objectives of this activity are 1) to determine the distribution of radioactivity in the unsaturated tuff matrix, using an unsaturated tuff block of the PTn or CH, and 2) to fit the uptake of radionuclides as a function of time to a diffusion model with reactions (sorption) to determine the diffusivities and rate constants. In the event of more complex reaction mechanisms, higher order and irreversible reactions will be added to the computer code (Investigation 8.3.1.3.7).

8.3.1.3.7 Investigation: Studies to provide the information required on radionuclide retardation by all processes along flow paths to the accessible environment

Purpose and objectives of the investigation

The purpose of this investigation is to support the total systems performance calculations of Issue 1.1 (Section 8.3.5.13). The goal of this investigation is to use the three-dimensional transport model and other multidimensional process codes to support Issue 1.1 and to determine, characterize, and quantify the cumulative effects of all significant processes, physical and geochemical, acting on or controlling radionuclide transport at Yucca Mountain.

8.3.1.3.7.1 Study: Retardation sensitivity analysis

The objectives of this study are 1) to develop a conceptual geochemical-geophysical description of Yucca Mountain based on the results, data, and information generated from the geochemistry, mineralogy-petrology, hydrology, and other pertinent YMP tasks, and 2) to determine what data may be inadequate or insufficient to make the cumulative, integrated transport calculations needed to meet

the NRC and EPA regulations. The calculations will be made during the fulfillment of Information Needs 1.1.4, and 1.1.5 (Sections 8.3.5.13.4 and 8.3.5.13.5).

8.3.1.3.7.1.1 Activity: Analysis of physical/chemical processes affecting transport

Objectives

This activity will 1) analyze all the processes that may affect transport; geochemical transport processes, physical transport processes, particulate transport, heat-load effects, and coupled phenomena, 2) support and develop those laboratory experiments designed to examine the physical and geochemical processes affecting radionuclide transport and other experimental activities under this program and the exploratory shaft tests (i.e., diffusion experiments), and 3) correlate and validate of results obtained from laboratory, exploratory shaft, and field experimental results with transport calculations.

8.3.1.3.7.1.2 Activity: Geochemical/geophysical model of Yucca Mountain and integrated geochemical transport calculations

Objectives

The objective of this activity is to perform calculations of radionuclide transport from the repository to the accessible environment using, as a basis, an integrated, conceptual geochemical-geophysical model of Yucca Mountain.

8.3.1.3.7.1.3 Activity: Transport models and related support

Objectives

The objective of this activity is to verify the computer codes and to validate the models used in this study and to identify important contributors to the uncertainties in retardation calculations (sensitivity analyses).

8.3.1.3.7.2 Study: Demonstration of applicability of laboratory data to repository transport calculations

The objectives of this study are 1) to demonstrate the validity of laboratory generated radionuclide transport process data and the validity of transport calculations using that data; and 2) to test models of radionuclide transport for their applicability to Yucca Mountain. This study will provide input as to the adequacy of retardation values by sorption for (Investigation 8.3.1.3.4), retardation by diffusive, dispersive, and advective transport processes (Investigation 8.3.1.3.6), applicability of models used to describe water flow and radionuclide transport at Yucca Mountain (Study 8.3.1.3.7.1) and support resolution of Issue 1.1 and total systems performance calculations

described in Section 8.3.5.13. This study will use controlled tests and analogues to achieve its goals. The proposed field tests in this study will be conducted in the unsaturated zone. Saturated zone testing for the same goals is presented in the Testing of the C-Hole Sites with Reactive Tracers and Well Testing with Reactive Tracers Throughout the Site (Activities 8.3.1.2.3.1.7 and 8.3.1.2.3.1.8, respectively).

8.3.1.3.7.2.1 Activity: Intermediate-scale experiments

Objectives

The goal of this activity is to conduct experiments at a scale larger than laboratory but with sufficient control on material and boundary conditions to test how increased spatial scale affects water flow and radionuclide transport in unsaturated porous media.

8.3.1.3.7.2.2 Activity: Field-scale experiments to study radionuclide transport at Yucca Mountain

Objectives

The goal of this activity is to evaluate the validity of laboratory derived data and models for radionuclide transport at the Yucca Mountain site by conducting tests in the bedded tuffs of the CH unit underlying the TS unit.

8.3.1.3.7.2.3 Activity: Natural analog studies of radionuclide transport

Objectives

The goal of this activity is to use natural analog studies and data generated by natural analogue studies to support long term calculations of radionuclide transport using laboratory data and radionuclide transport models.

8.3.1.3.7.2.4 Activity: Data on radionuclide transport from other U.S. Department of Energy sites (Anthropogenic Analogs)

The goal of this activity is to evaluate the validity of laboratory derived data and models for radionuclide transport at the Yucca Mountain site by obtaining data collected at other U.S. Department of Energy (DOE) sites on radionuclide distribution in geologic systems.

8.3.1.3.8 Investigation: Studies to provide the required information on retardation of gaseous radionuclides along flow paths to the accessible environment

Purpose and objectives of the investigation

The purpose of this investigation is to supply input data for calculations of gaseous radionuclide transport from the repository to the accessible environment at the Yucca Mountain site. The objective of this investigation is to provide the data necessary for developing a chemical model that can be used to calculate this residence time. The residence time can then be used to calculate the rates of transport of gaseous radionuclide species between the repository and the accessible environment, and to verify experimentally the models of gaseous radionuclide transport and retardation that are used to assess radionuclide release.

8.3.1.3.8.1 Study: Gaseous radionuclide transport calculations and measurements

The goal of this study is (1) to calculate the rates of transport of gaseous radionuclide species (Activity 8.3.1.3.8.1.1) between the repository and the accessible environment considering the various driving forces and retardation mechanisms that may exist and (2) to experimentally verify potential existing models of gaseous radionuclide transport and retardation that are used to assess radionuclide release to the environment.

8.3.1.3.8.1.1 Activity: Physical transport mechanisms and rates--retardation mechanisms and transport with retardation

Objectives

The goals of this activity are 1) to determine the manner in which gaseous species are transported in the unsaturated zone and to calculate transport rates without retardation, and 2) to identify the retardation mechanisms that can affect the transport of gaseous species through the unsaturated zone and model these processes so that the effects on transport rates can be evaluated.

8.3.1.3.8.1.2 Activity: Gas transport measurements

Objectives

The goal of this activity is to measure experimentally gas transport rates under typical unsaturated zone conditions to verify calculational models of gas transport and retardation, if they exist.

8.3.1.4 Objectives of the rock characteristics program

Summary of performance and design requirements for rock characteristics information

Compliance with performance and design criteria for a geologic repository will require information about the rock characteristics of the Yucca Mountain site. This information will be used in the design of underground repository facilities and to support assessments of site performance related to ground-water travel time, waste-package lifetime, radionuclide releases from the EBS, and radionuclide releases to the accessible environment. The various regulatory requirements are concerned with rock characteristics, conditions, and processes in different subsurface regions within and around Yucca Mountain. The rock characteristics are also an important component of model validation, particularly for establishing the boundary and initial conditions and the geometry of the model.

The siting criteria discussed in 10 CFR 60.122 must also be evaluated, including the favorable condition for waste emplacement at a minimum depth of 300 m and characterization of structural, stratigraphic, and geomechanical conditions to determine if potentially adverse conditions are present. Design criteria for the underground facility, seals of shafts and boreholes, and waste packages are also evaluated in the context of the natural rock properties of the site. Assessments of whether the performance objectives, siting criteria, and design criteria can be met will rely on information about the stratigraphy and structure of the Yucca Mountain site, the properties of the rock units occurring at the site, and the temperature and stress conditions before excavation of underground openings.

8.3.1.4.1 Investigation: Development of an integrated drilling program and integration of geophysical activities

This investigation is composed of two planning and evaluation activities. The first activity is designed to provide a mechanism for overall integration of the surface-based activities to be conducted during site characterization. Integration is important to ensure that the data needed to improve site models for use in performance assessment and repository design are obtained in an efficient and cost-effective manner. The second activity is designed to provide a focal point for integration of all geophysical site characterization activities. Because geophysical activities provide data to a number of site programs, as well as to both performance and design issues, it is important that the planned activities are periodically reviewed to determine if the data base being developed is adequate for the range of planned uses.

8.3.1.4.1.1 Activity: Development of an integrated drilling program

Objectives

The objectives of this activity are to

1. Ensure representativeness of data acquired during surface-based site characterization activities and that data represent the range of phenomena and structural characteristics needed for performance assessment.

2. Integrate and prioritize surface-based activities to produce a schedule that best addresses representativeness and efficacy concerns, given budgetary constraints. Monitor conformance with plans, especially with respect to site performance impact (particularly the nature and extent of surface disturbance, fluid use, and penetrations of the unsaturated zone and the repository horizon). Review planned activities with respect to methodology, monitor activities in progress, and provide a means to effect changes if necessary. Address sample and data requirements through linkage and integration with other activities.

3. Maintain a system of technical element baseline approval and control. Such a system is needed to ensure conformance with planning and integration, and to control changes to plans that have the potential to adversely impact site performance; testing interference; or data and samples exchanged between activities.

8.3.1.4.1.2 Activity: Integration of geophysical activities

Objectives

This activity will provide a mechanism for information exchange, an analysis of data and other technical information, and an overview of planned geophysical site characterization activities. The objectives for geophysics integration are to increase 1) the effectiveness of planned geophysical surveys through consideration of past efforts both within and outside the YMP and 2) the overall effectiveness of geophysical exploration by analysis of how each planned survey addresses specific information requirements for site licensing.

8.3.1.4.2 Investigation: Geologic framework of the Yucca Mountain site

Purpose and objectives of the investigation

The objectives of this investigation are 1) to provide primary data on the lateral and vertical variations in site stratigraphy through acquisition of borehole cores and cuttings and surface geologic mapping, 2) to provide information that will allow three-dimensional modeling (through the use of borehole and surface geophysical surveys) of the variation in properties of interest between points of primary data, and 3) to provide information on the lateral and vertical variation of structural elements that may affect in situ properties of interest (e.g., fracture-related flow) in conjunction with site characterization investigations on geohydrology, geochemistry, postclosure tectonics, and seismicity (i.e., preclosure tectonics) (Sections 8.3.1.2, 8.3.1.3, 8.3.1.8, and 8.3.1.17).

8.3.1.4.2.1 Study: Characterization of the vertical and lateral distribution of stratigraphic units within the site area

The objective of this study is to determine the vertical and lateral variability and emplacement history of stratigraphic units and lithostratigraphic subunits within the Yucca Mountain site area.

8.3.1.4.2.1.1 Activity: Surface and subsurface stratigraphic studies of the host rock and surrounding units

Objectives

The objective of this activity is to determine the spatial distribution, history, and characteristics of stratigraphic units within the Paintbrush Tuff, tuffaceous beds of CH, Crater Flat Tuff, and possibly older volcanic rocks within the site area.

8.3.1.4.2.1.2 Activity: Surface-based geophysical surveys

Objectives

The objective of this activity is to improve confidence in stratigraphic models of Yucca Mountain by incorporating geophysical constraints.

8.3.1.4.2.1.3 Activity: Borehole geophysical surveys

Objectives

The objectives for this activity are 1) to aid in the definition and refinement of the location and character of lithostratigraphic units and contacts between units and 2) to determine the distribution of rock properties within lithostratigraphic units.

8.3.1.4.2.1.4 Activity: Petrophysical properties testing

Objectives

The objective of this activity is to provide geophysical and rock property data to be used in the interpretation of surface-based and borehole geophysical surveys.

8.3.1.4.2.1.5 Activity: Magnetic properties and stratigraphic correlations

Objectives

The objectives of this activity are to

1. Provide magnetic property data to aid the interpretation of volcanic stratigraphy and structure of rock units within the Yucca Mountain site area.

2. Use paleomagnetic directions to provide orientations for drill core segments.

3. Assess the rotation of rock units in relation to the geologic structures of Yucca Mountain from paleomagnetic indications.

8.3.1.4.2.2 Study: Characterization of the structural features within the site area

The objective of this study is to determine the frequency, distribution, characteristics, and relative chronology of structural features within the Yucca Mountain site area.

8.3.1.4.2.2.1 Activity: Geologic mapping of zonal features in the Paintbrush Tuff

Objectives

The objectives of this activity are 1) to map zonal variations within exposed tuffs that will aid in the identification of structural displacements at a scale of 10 m or less, and 2) to detect subtle changes in structural styles.

8.3.1.4.2.2.2 Activity: Surface-fracture network studies

Objectives

The objective of this activity is to provide measurements and analyses of fracture networks to support modeling of hydrologic potential flowpaths, particularly in unsaturated zones. Applications are also expected to aid development of tectonic models and determination of the mechanical response of fractured rock to excavation and thermal loading. The analyses will provide quantitative data for determining spatial distribution of fractures, chronology of fracture development, and parametric characteristics of fractures. Applications are expected to aid in the development of tectonic models and possibly to aid in the determination of the bulk response of fractured rock in the context of excavation and loading.

8.3.1.4.2.2.3 Activity: Borehole evaluation of faults and fractures

Objectives

The objectives of this activity are to

1. Assess the reliability and usefulness of available borehole techniques for identifying and characterizing the subsurface fracture distribution.

2. Determine vertical and lateral variability and characteristics of subsurface fractures.

3. Identify subsurface characteristics of fault zones.

8.3.1.4.2.2.4 Activity: Geologic mapping of the Exploratory Studies Facility

Objectives

The objectives of this activity are to

1. Determine the vertical and horizontal variability of fracture networks in the ESF ramps, drifts, and boreholes.

2. Characterize major faults and fault zones in the subsurface.

3. Map the lithostratigraphic features of the subunits, and the abundance and character of lithophysal zones.

4. Assist in evaluation of test locations in the ESF.

8.3.1.4.2.2.5 Activity: Seismic tomography/vertical seismic profiling

Objectives

The objectives of this activity are to

1. Investigate, and if successful, provide a means for broadly detecting and characterizing the subsurface fracture network in regions between the surface, boreholes, and underground workings.

2. Calibrate and relate the seismic propagation characteristics of the host rock to the fracture patterns observed in boreholes and underground workings, and to extrapolate the observed fracture patterns to the surrounding region.

8.3.1.4.2.3 Study: Three-dimensional geologic model

Objectives

The objective of this study is to develop a three-dimensional geologic model of the site area. In doing so, much of the study will involve synthesis of the results of other studies in the investigation to develop a model that will be integrated into the three-dimensional rock characteristics model described in Study 8.3.1.4.3.2 of Investigation 8.3.1.4.3.

8.3.1.4.2.3.1 Activity: Development of a three-dimensional geologic model of the site area

Objectives

The objective of this activity is to develop a three-dimensional geologic model of the Yucca Mountain site that incorporates stratigraphic, structural, geophysical, and rock properties information pertinent to site characterization, and design and performance assessment activities.

8.3.1.4.3 Investigation: Development of three-dimensional models of rock characteristics at the repository site

Purpose and objectives of the investigation

The purpose of developing three-dimensional, computer-based models of rock characteristics at the Yucca Mountain site is two-fold: 1) to summarize information gained during the course of Investigations 8.3.1.4.2 (geologic framework), 8.3.1.2.1 through 8.3.1.2.3 (hydrologic material properties), (thermal/mechanical properties) and 2) to provide a mechanism for transfer of this integrated information to the design and performance assessment issues.

Specifically, performance assessment and design issues have called for quantitative information regarding the spatial distribution of various rock characteristics. Numerous investigations have been designed to acquire the basic quantitative data or to develop the geologic framework that must be considered in the development of a three-dimensional model of rock characteristics.

8.3.1.4.3.1 Study: Systematic acquisition of site-specific subsurface information

Only one activity is planned under this study.

8.3.1.4.3.1.1 Activity: Systematic drilling program

Objectives

This activity will acquire physical rock samples, analytical data, and basic descriptions of the subsurface geology of the repository site on a systematic basis. These samples and information are important for characterizing the three-dimensional distribution of rock characteristics, and hydrologic and geochemical variables, for the unsaturated zone at Yucca Mountain. Other information and samples will also be provided because of this access to the shallow saturated zone.

Borehole locations and drilling methods used by this activity are technically and programmatically integrated with other activities, including 8.3.1.2.2.3.2 (site vertical boreholes study), 8.3.1.2.3.1.1 (Solitario Canyon fault study in the saturated zone), and 8.3.1.2.3.1.2 (site potentiometric-level evaluation). Consistent with the requirements of 10 CFR 60(d)(4), the location and drilling of the boreholes in the systematic drilling program are being coordinated with the

repository design. The integration and coordination of these activities will be accomplished in Activity 8.3.1.4.1.1, development of an integrated drilling program.

8.3.1.4.3.2 Study: Three-dimensional rock characteristics models

8.3.1.4.3.2.1 Activity: Development of three-dimensional models of rock characteristics at the repository site

Objectives

The objective of this activity is to develop computer-based three- dimensional models that integrate quantitative and semiquantitative data on rock characteristics in light of constraining information developed by studies of the geologic framework of the Yucca Mountain site (Investigation 8.3.1.4.2).

8.3.1.5 Objectives of the climate program

Summary of performance and design requirements for climate information

Certain performance and design issues address requirements that climate and climate-related factors be determined for past, present, and future conditions (Investigation 8.3.1.5.1) and that the effects of future climate on hydrology be determined (Investigation 8.3.1.5.2). The results of Investigation 8.3.1.5.1 are necessary inputs to Investigation 8.3.1.5.2. More data are required than are presently available on the paleohydrology, paleoclimate, and modern climate of the Yucca Mountain area in order to adequately predict future climate and its possible effect on site hydrology relative to repository performance.

Plans for two investigations making up the climate program are given in Sections 8.3.1.5.1 and 8.3.1.5.2. Other plans for site investigations requiring climate information include those for the erosion program (Section 8.3.1.6), the geochemistry program (Section 8.3.1.3), the preclosure hydrology program (Section 8.3.1.16), and the geohydrology program (Section 8.3.1.2).

The climate program consists of investigations designed to provide data on past, present, and future climate conditions and to determine the effects of climate change on surface, unsaturated-zone, and saturated-zone hydrology. Specifically, determining the effects of future climate on geohydrology helps to satisfy the following performance and design issues.

Issue	Short title	SCP section
1.1	Total system performance (the system performance objective for limiting radionuclide releases to the accessible environment as required by 10 CFR Part 60 and 40 CFR 191.13)	8.3.5.13

Issue	Short title	SCP section
1.8	NRC siting criteria (the favorable and potentially adverse conditions of 10 CFR Part 60)	8.3.5.17
1.9a	Higher level findings (postclosure) of 10 CFR Part 960: (1) 960.4-2-1, qualifying condition for geohydrology, (2) 960.4-2-4, qualifying condition for climate	8.3.5.18
1.9b	Comparative evaluation over next 100,000 yr	8.3.5.18
1.10	Waste package characteristics (postclosure)	8.3.4.2
1.11	Configuration of underground facilities (postclosure)	8.3.2.2
1.12	Seal characteristics	8.3.3.2

For the 10,000-yr period (Issues 1.1, 1.8, 1.9a, 1.10, 1.11, and 1.12), it has been determined that information needed to satisfy Issue 1.1 will be sufficient to address Issues 1.8, 1.9a, 1.10, 1.11, and 1.12. However, to satisfy Issue 1.9b (the comparative evaluation over the next 100,000 yr), additional information is required within the climate program, including additional data and slightly different modeling strategies (Section 8.3.1.5.1.6.2).

The investigations, studies, and activities within the climate program are designed to provide estimates of future climatic conditions and estimates of the effects of future climate on hydrologic conditions.

8.3.1.5.1 Investigation: Studies to provide the information required on nature and rates of change in climatic conditions to predict future climates

Purpose and objectives of the investigation

Investigation 8.3.1.5.1 provides information to help satisfy performance and design Issues 1.1, 1.8, 1.9a and b, 1.10, 1.11, and 1.12. Recent meteorological data and Great Basin historical climate data will be used to calibrate (using present conditions) and validate (using past conditions) models of future climate. A paleoclimate-paleoenvironment synthesis will be derived from lake, playa, and marsh sediments, pack rat middens, vegetation calibrations, and soil and surficial deposits. This synthesis will provide time-sequential reconstructions for the modeling activities as well as for Investigation 8.3.1.5.2. These models will attempt to forecast climatic variables for the next 100,000 yr to determine climatic conditions.

8.3.1.5.1.1 Study: Characterization of modern regional climate

The objective of this study is to provide a baseline and a background for the interpretation of climatic variation. Characterization of the synoptic climate will result in the determination of modern spatial and temporal variations in precipitation, air temperature, cloud cover, and other meteorological variables. These data will be used in the development of modern vegetation-climate calibration relationships, in the assessment of lake-climate relationships, and in the development and testing of climate circulation models and in specifying relationships between global-scale circulation patterns and the regional and local climate features of relevance to site performance coordinated by the overview activity in Section 8.3.1.12.1.2.

In cooperation with meteorology program (8.3.1.12) and geohydrology program (8.3.1.2), efforts will be made to relate modern storms (and their trajectories) to the isotopic signatures of infiltrating ground water. This analysis will be assisted by modeling of the carbon isotope systematics in ground water. These data may provide insight into past air-mass trajectories and will be available to the climatology program.

8.3.1.5.1.1.1 Activity: Synoptic characterization of regional climate

Objectives

The objectives of this activity are to

1. Provide the basis for developing vegetation-climate relationships, lake-climate relationships, and climate-circulation models (meteorological data).

2. Provide an understanding of spatial and temporal variation in climate (synoptic climate).

3. Determine the climate conditions (i.e., time, temperature, seasonality, and air masses) under which recharge occurs (isotopic data).

8.3.1.5.1.2 Study: Paleoclimate study: lake, playa, marsh deposits

This study will establish the nature, timing, duration, and amplitude of paleoclimate changes based on analyses of paleontologic, geochemical, and stratigraphic-sedimentologic data obtained from lacustrine sediments in or near southern Nevada.

8.3.1.5.1.2.1 Activity: Paleontologic analyses

Objectives

The objective of this activity will be to assemble and interpret, in paleoclimatic terms, detailed records of ostracodes, diatoms, and pollen, along with other types of fossils as warranted by specific paleoclimatic questions. This record will involve collection, identification, enumeration, and

interpretation of paleontologic data that emphasizes the past 50,000 yr in great detail, the past 200,000 yr in moderate detail, and the past 1,000,000 yr in some detail. Calcareous fossils will also be collected for geochemical and age analyses of their carbonate.

8.3.1.5.1.2.2 Activity: Analysis of the stratigraphy-sedimentology of marsh, lacustrine, and playa deposits

Objectives

The objectives of this activity are to

1. Identify and characterize the general physical and chemical properties of sedimentary units from outcrops, shore deposits, and cores. This information will provide a physical and relative temporal framework within which various paleoenvironmental studies will be made.

2. Determine the specific environment of deposition for the sedimentary units using the principles of clastic and chemical sedimentology.

8.3.1.5.1.2.3 Activity: Geochemical analyses of lake, marsh, and playa deposits

Objectives

The objective of this activity is to provide a detailed chemical and mineralogic characterization of all sediments to provide information about the chemistry of the water from which the minerals precipitated and to determine sediment provenance.

8.3.1.5.1.2.4 Activity: Chronologic analyses of lake, playa, and marsh deposits

Objectives

The objective of this activity is to obtain an accurate, precise chronologic framework for the paleoclimatic information acquired in this study. Moreover, all age information should, whenever possible, be tested with other techniques to reduce uncertainties.

8.3.1.5.1.3 Study: Climatic implications of terrestrial paleoecology

This study will provide quantitative estimates of changes in climatic variables (e.g., precipitation and temperature) for the southern Great Basin. Plant macrofossils from pack rat middens will provide coverage for the last 50,000 yr (Activity 8.3.1.5.1.3.1), while fossil pollen from land plants recovered from cores of lacustral sediments will cover at least the last 150,000 yr (Activity 8.3.1.5.1.3.2). Transfer functions, response surfaces, or both will be developed through the statistical comparisons of

modern climate to the vegetation data, and these equations will be used in the reconstructions of past climates from the paleovegetation data (Activity 8.3.1.5.1.3.3).

8.3.1.5.1.3.1 Activity: Analysis of pack rat middens

Objectives

The objective of this activity is to determine the nature, timing, duration, and magnitude of past vegetation change as recorded in plant macrofossil assemblages preserved in ancient pack rat middens.

8.3.1.5.1.3.2 Activity: Analysis of pollen samples

Objectives

The objective of this activity is to determine the nature, timing, duration, and magnitude of past vegetation change as recorded in the stratigraphic record of fossil pollen grains.

8.3.1.5.1.3.3 Activity: Determination of vegetation-climate relationships

Objectives

The objective of this activity is to translate the vegetational records provided by pack rat midden and palynological investigations and available dendroclimatological data into quantitative estimates of past climatic variables.

8.3.1.5.1.4 Study: Analysis of the paleoenvironmental history of the Yucca Mountain region

The objective of this study is to evaluate the paleoenvironmental record at Yucca Mountain and surroundings in the light of the inferred paleoclimate history of the southern Great Basin. It also provides information to distinguish between effects resulting from surficial processes, as opposed to tectonic activity, and to evaluate the age of tectonic events. The chronology of the erosional and depositional responses to climatic changes at Yucca Mountain will be used to cross-check and supplement the reconstruction of paleoclimate. A detailed paleoenvironmental history is needed to distinguish short- and long-term tectonic effects from local climatic controls on surficial processes. Therefore, dated deposits in this study will be used to constrain ages and recurrence intervals of fault movements.

8.3.1.5.1.4.1 Activity: Modeling of soil properties in the Yucca Mountain region

Objectives

The objectives of this activity are to

1. Determine the relations among properties of late Holocene soils and modern climatic parameters.

2. Compare properties of selected soils at Pahute Mesa and areas near Tonopah, which have formed under conditions similar to those that may have existed at Yucca Mountain during pluvial conditions of Pleistocene glacial climatic cycles.

3. Compare properties of early Holocene and Pleistocene soils to paleoclimatic models that are reconstructed from other lines of evidence, such as paleolimnology and terrestrial paleoecology, as a check on these models.

4. Frame climatic scenarios as a function of the depth, distribution, and quantity of pedogenic carbonate and other soil parameters.

5. Quantify rates of soil development in specific climates for use as a dating tool for Quaternary deposits and ages of fault movements.

8.3.1.5.1.4.2 Activity: Surficial deposits mapping of the Yucca Mountain area

Objectives

The objectives of this activity are to

1. Determine the distribution, age, genesis, soil properties, and physical properties of surficial deposits at Yucca Mountain and surroundings.

2. Evaluate the influences of climate and tectonics on the genesis of surficial deposits.

3. Provide a map of surficial deposits for facility placement planning, geomorphic studies, engineering property studies, and surface infiltration studies.

4. Determine the distribution of major concentrations of calcite-silica vein deposits at or near the ground surface at Yucca Mountain.

8.3.1.5.1.4.3 Activity: Eolian history of the Yucca Mountain region

Objectives

The objectives of this activity are

1. Document eolian erosion and deposition in the Yucca Mountain area during the last 750,000 yr.

2. Determine paleoenvironmental conditions during times of eolian deposition and intervening times of surface stability and soil formation.

3. Determine source areas of sand and silt.

8.3.1.5.1.5 Study: Paleoclimate-paleoenvironmental synthesis

This study consists of one activity and will compare the paleoclimatic estimates from the various proxy data sets and provide data syntheses in the formats required for future climate and paleohydrology investigations.

8.3.1.5.1.5.1 Activity: Paleoclimate-paleoenvironmental synthesis

Objectives

The objective of this activity is to provide summaries of the paleoclimatic data in formats that can be utilized by investigations of future climatic changes and paleohydrology.

8.3.1.5.1.6 Study: Characterization of the future regional climate and environments

The objective of this study is to estimate values for climatic parameters for the Yucca Mountain area over the next 100,000 yr, with special emphasis on the next 10,000 yr. The values for these parameters will be used in the hydrologic modeling of the ground-water regime at Yucca Mountain (Investigation 8.3.1.5.2) and in the investigation of the effects of future climate on erosion at Yucca Mountain (Investigation 8.3.1.6.2). Estimates for future precipitation, temperature, evapotranspiration, and other parameters will result from the modeling of certain climate scenarios expected to occur in the southern Great Basin over the next 100,000 yr.

8.3.1.5.1.6.1 Activity: Global climate modeling

Objectives

The objectives of this activity are to

1. Identify and estimate factors controlling global climate.

   a. Develop a sequence of "snapshots" of possible climate scenarios at intervals of up to 1,000 yr over the next 10,000 yr.

b. Develop a set of anticipated global climate scenarios over the next 100,000 yr.

2. Compute the configuration and extent of ice sheets at regular intervals of time over the next 100,000 yr to determine the effects of such ice volume changes upon the climatic system.

3. Provide boundary conditions, including precipitation, temperature, cloud cover, evapotranspiration, and wind velocity for regional climate models through the use of general circulation models.

8.3.1.5.1.6.2 Activity: Regional climate modeling

Objectives

The objective of this activity is to establish the feasibility of using a regional scale numerical climate model for predicting future climatic conditions at Yucca Mountain. If this task is accomplished, the model will be calibrated against modern climatic data and validated with paleoclimatic data.

8.3.1.5.1.6.3 Activity: Linked global-regional climate modeling

Objectives

The objectives of this activity are to

1. Formulate reasonable hypotheses for scenarios of future climate in the southern Great Basin and Yucca Mountain over the next 100,000 yr, with emphasis on the next 10,000 yr.

2. Model meteorological parameters of expected climate scenarios for the southern Great Basin.

3. Use the quantitative meteorologic descriptions resulting from the modeling of future climate scenarios to derive measurements of climate parameters to be used in hydrologic modeling of the Yucca Mountain area and in investigating the effects of climate on erosion at Yucca Mountain.

8.3.1.5.1.6.4 Activity: Empirical climate modeling

Objectives

The objectives of this activity are to

1. Formulate reasonable hypotheses for scenarios of future climate in the southern Great Basin and Yucca Mountain over the next 100,000 yr, with emphasis on the next 10,000 yr.

2. Model meteorological parameters of expected climate scenarios for the southern Great Basin.

3. Use the quantitative meteorologic descriptions resulting from the modeling of future climate scenarios to derive measurements of climate parameters to be used in hydrologic modeling of the Yucca Mountain area and in investigating the effects of climate on erosion at Yucca Mountain.

8.3.1.5.2 Investigation: Studies to provide the information required on potential effects of future climatic conditions on hydrologic characteristics

Purpose and objectives of the investigation

This investigation provides information to help satisfy performance and design Issues 1.1, 1.8, 1.9a and b, and 1.10. Reconstructions from Investigation 8.3.1.5.1 along with past surface water, and unsaturated- and saturated-zone characterizations will lead to an understanding of the Quaternary regional hydrologic regime. This information along with models of future climate conditions and estimates of future meteorological conditions from Investigation 8.3.1.2.1, and models of the unsaturated and saturated zones from the geohydrology program (Section 8.3.1.2) will help determine the effects of climate change on geohydrology. This will require the development of a relationship between climate, infiltration, and recharge.

8.3.1.5.2.1 Study: Characterization of the Quaternary regional hydrology

The objective of this study is to characterize the distribution of surface water, the unsaturated zone infiltration and percolation rates, and the ground-water potentiometric levels during the Quaternary Period in the vicinity of Yucca Mountain.

8.3.1.5.2.1.1 Activity: Regional paleoflood evaluation

Objectives

The objectives of this activity are to

1. Identify the locations and investigate the hydraulic characteristics of paleoflood events, and compare this evidence with the locations and characteristics of modern flooding and geomorphic processes. These findings and comparisons will improve knowledge of the relationships between climate and flooding.

2. Assess the character and severity of paleoflood and debris hazards to assess the potential of flood and debris hazards for the repository during the preclosure period.

8.3.1.5.2.1.2 Activity: Quaternary unsaturated zone hydrochemical analysis

This activity intentionally omitted: the proposed scope of work will be performed in Activity 8.3.1.2.2.7.2 (Aqueous-phase chemical investigations).

8.3.1.5.2.1.3 Activity: Evaluation of past discharge areas

Objectives

The objectives of this activity are to

1. Determine the location, type, and extent of hydrogeologic units in the ground-water discharge areas of the Amargosa Desert and Death Valley.

2. Understand the past quantity and quality of water in the discharge areas of Franklin Lake, Amargosa Desert-River, and Peter's Playa and to determine the paleohydrologic significance of Peter's Playa and Franklin Lake as discharge areas.

3. Determine the location and hydrogeologic characteristics of paleospring deposits in the discharge area.

4. Determine the location and amount of discharge by evapotranspiration that has occurred at past discharge sites.

5. Understand the past and present discharge areas of the regional hydrologic system in order to predict the future saturated zone hydrologic system at Yucca Mountain.

6. Determine past ground-water levels in carbonate caverns as evidence of past hydrologic conditions.

8.3.1.5.2.1.4 Activity: Analog recharge studies

Objectives

The objective of this activity is to estimate the conditions and rates of ground-water recharge (infiltration) during the Quaternary in the vicinity of Yucca Mountain.

8.3.1.5.2.1.5 Activity: Studies of calcite and opaline silica vein deposits

Objectives

The objective of this activity is to determine the ages, distribution, origin, and paleohydrologic significance of calcite and opaline silica deposits along faults and fractures in the vicinity of Yucca Mountain.

8.3.1.5.2.2 Study: Characterization of the future regional hydrology due to climate changes

The objective of this study is to characterize the impacts of potential future climate changes on the regional and site surface-water system, the site unsaturated-zone hydrology, and the regional and site saturated-zone hydrology.

8.3.1.5.2.2.1 Activity: Analysis of future surface-water hydrology due to climate changes

Objectives

The objectives for this activity are to

1. Simulate past changes in runoff and surface-water storage (lakes) resulting from past climatic change.

2. Use the relationship between paleoclimate and paleo surface-water conditions to predict the impact of future climatic conditions on surface-water hydrology at the site.

8.3.1.5.2.2.2 Activity: Analysis of future unsaturated zone hydrology due to climate changes

This activity was intentionally deleted; the scope of work for this activity will be performed in Activity 8.3.1.2.2.9.5 (Site unsaturated-zone integration and synthesis).

8.3.1.5.2.2.3 Activity: Evaluation of possible future changes of the climate and regional geologic framework on the regional saturated zone hydrology.

Objectives

The objectives of this activity are to

1. Reconstruct paleohydrologic conditions at Yucca Mountain and use these conditions together with the paleoclimatic conditions reconstructed under Investigation 8.3.1.5.1 as a basis to predict the impact of future climatic conditions on the saturated-zone hydrologic system.

2. Synthesize the existing paleohydrologic data through the use of numerical simulation techniques to determine the effects that greater recharge would have on water-table altitude, ground-water flow paths, and hydraulic gradients between Yucca Mountain and the accessible environment.

3. Evaluate possible regional tectonic and thermal events that may produce prolonged or transient effects on the regional water level.

8.3.1.6 Objectives of the erosion program

Summary of performance and design requirements for erosion information

The following summarizes the requirements for erosion data from the design and performance issues:

1. The surface characteristics program (8.3.1.14) requires information on the expected magnitude and locations of erosion both on bedrock and alluvial-colluvial surfaces.

2. Issue 1.12 (Section 8.3.3.2, seal characteristics) requires information on the erosion potential (rates) near shafts to support the design of seals.

3. The human interference program (8.3.1.9) requires information on erosion to determine the most suitable locations for the surface markers and monuments of the warning system.

8.3.1.6.1 Investigation: Studies to determine present locations and rates of surface erosion

Objectives of the investigation

The objectives of this investigation are to obtain the site-specific data needed to calculate average Quaternary hillslope erosion rates and accurate average short-term erosion rates associated with episodic erosion. This investigation will perform three activities and use information from the climate (Section 8.3.1.5) and geohydrology (Section 8.3.1.2) programs to support these objectives. Three kinds of data will be obtained to characterize past distribution of hillslope and alluvial deposits, and surfaces of different ages will be shown on a geomorphic map of Yucca Mountain. First, the map will show the extent to which modern erosion has affected an essentially Pleistocene landscape. Second, local stream incision rates will be calculated by dating incised stream terraces and sand ramps by uranium-trend, uranium-series, radiocarbon, and cation ratio (rock varnish) dating methods. Third, average erosion rates on hillslopes will be calculated from dated hillslope surfaces by the rock varnish dating method.

8.3.1.6.1.1 Study: Distribution and characteristics of present and past erosion

The objectives of this study are to identify the erosional processes that have been operating in the Yucca Mountain area during the Quaternary, to identify the specific locations of past erosion, and to quantify the rates of the different processes and assess their relative importance.

8.3.1.6.1.1.1 Activity: Development of a geomorphic map of Yucca Mountain

Objectives

The objectives of this activity are to (1) determine the areal distribution of active erosional areas and geomorphically stable areas and (2) determine the spatial distribution of the different types of

geomorphic processes and associated deposits. This activity will synthesize data collected in Studies 8.3.1.5.1.4 and 8.3.1.17.4.6.

8.3.1.6.1.1.2 Activity: Analysis of the downcutting history of Fortymile Wash and its tributaries

Objectives

The objectives of this activity are to (1) determine stream-incision rates on Fortymile Wash and selected tributaries and (2) determine the cause(s) of the major downcutting episode(s) on Fortymile Wash. This activity will synthesize data collected in Studies 8.3.1.5.1.4 and 8.3.1.16.1.1.

8.3.1.6.1.1.3 Activity: An analysis of hillslope erosion at Yucca Mountain

Objectives

The objectives of this activity are to (1) determine the average rates of Quaternary hillslop erosion on Yucca Mountain in bedrock and surficial deposits and (2) determine the genesis and the rates of movement of hillslope deposits. This activity will synthesize data collected in Study 8.3.1.5.1.4.

8.3.1.6.2 Investigation: Potential effects of future climatic conditions on locations and rates of erosion

Objectives of the investigation

A projected sequence of climatic episodes, including the timing for their initiation and duration, will result from the climate modeling for Investigation 8.3.1.5.1. Studies for Investigation 8.3.1.6.1 will characterize present and past locations and rates of erosion in the Yucca Mountain region. Fitting the projected future climate sequence with corresponding known erosion rates and past geomorphic responses will allow the quantification of erosion effects at Yucca Mountain over the next 10,000 yr.

8.3.1.6.2.1 **Study: Influence of future climatic conditions on locations and rates of erosion**

The objectives of this study are to determine the effects of future climatic conditions on the locations and rates of erosion. This synthesis study will use climate and erosion parameters generated by Investigations 8.3.1.5.1 and 8.3.1.6.1 to identify areas and rates of potential stream incision and increased erosion.

8.3.1.6.2.1.1 Activity: Synthesis and data evaluation of impact of future climatic conditions on locations and rates of erosion

Objectives

The objectives of this activity are to integrate Quaternary climate conditions and rates of surface erosion with predicted conditions of future climate, and to estimate significant changes in the character, distribution, and ratio of surface erosion in the Yucca Mountain region over the next 1,000 to 100,000 yr.

8.3.1.6.3 Investigation: Studies to provide the information required to determine the potential effects of future tectonic activity on locations and rates of erosion

Objectives of the investigation

Estimates of the potential effects of future tectonic activity on locations and rates of erosion will be derived in this investigation using information from Investigation 8.3.1.8.2, from Investigation 8.3.1.5.1, and from other activities performed within this program.

8.3.1.6.3.1 Study: Evaluation of the effects of future tectonic activity on erosion at Yucca Mountain

The objective of this study is to identify the potential effects of tectonic activity on erosion at Yucca Mountain during the postclosure period. The study is aimed at (1) defining those components of erosion that are dependent upon tectonic activity, and (2) determining how future tectonic adjustment might influence local incision rates.

8.3.1.6.3.1.1 Activity: Synthesis and data evaluation of the impact of future uplift or substances and faulting on erosion at Yucca Mountain and vicinity

Objectives

The objectives of this activity are to estimate (1) the effects of tectonic activity on erosion over the repository postclosure period on the basis of probable future tectonic scenarios for the Yucca Mountain region, (2) the locations and rates of present and past erosion for present climatic conditions, and (3) the effects of future climatic conditions on erosion.

8.3.1.6.4 Development of a topical report to address the effects of erosion on the hydrologic, geochemical, and rock characteristics

Objectives of the investigation

The objective of this investigation is to develop a topical report on the effects of erosion on the ability of the site to isolate waste.

8.3.1.6.4.1 Study: Development of a topical report on the effects of erosion

The objective of this study is to compile site specific data from other studies, including a geomorphic map of Yucca Mountain (Studies 8.3.1.5.1.4 and 8.3.1.17.4.6); rates, locations and processes of erosion in Fortymile Wash and its tributaries (Studies 8.3.1.5.1.4 and 8.3.1.16.1.1); and average rates of hillslope erosion at Yucca Mountain (Study 8.3.1.5.1.4). This information will be used to develop a topical report on how the processes and rates of erosion in the Yucca Mountain area bear upon the ability of the site to isolate waste.

8.3.1.7 Overview of rock dissolution program: Description of rock dissolution required by the performance and design issues

Because the findings made for the Yucca Mountain environmental assessment (DOE, 1986b) are adequate to meet the requirements of Issue 1.8 (Section 8.3.5.17, NRC siting criteria) and 1.9 (Section 8.3.5.18, higher level findings--postclosure system and technical guidelines), no additional studies are specifically planned to resolve this issue. Further work related to chemical and mineralogical changes in the post-emplacement environment is discussed in Section 8.3.4.2.4.1. Studies on mineral stability are described in Section 8.3.1.3 (Geochemistry Program). These studies are being done to assess geochemical retardation along flow paths to support the assessments made in Issue 1.1 (total system performance, Section 8.3.5.13).

8.3.1.8 Objectives of the postclosure tectonics program

Summary of performance and design requirements for postclosure tectonics information

The performance and design requirements that the postclosure tectonics program must address are to supply data on the probability and effects of tectonic "initiating events" that may alter existing conditions at Yucca Mountain and adversely affect repository performance. These requirements for tectonic information can be summarized as follows:

1. Data on the probability and effects of potentially significant tectonic release-scenario classes addressing both anticipated and unanticipated conditions that are needed for performance assessment calculations of radionuclide releases to the accessible environment (Issue 1.1, Section 8.3.5.13, total system performance):

2. Data required to perform the analysis to determine the degree to which each of the favorable and potentially adverse conditions listed in 10 CFR 60.122 contributes to or detracts from isolation (Issue 1.8, Section 8.3.5.17, NRC siting criteria).

3. Data needed to accommodate requirements for knowledge of site-specific tectonic conditions in design concepts for the geometry, layout, and emplacement borehole locations of the underground facility (Issue 1.11, Section 8.3.2.2, configuration of underground facilities (postclosure)).

4. Data required so that the higher level findings of 10 CFR Part 960 can be evaluated (Issue 1.9a, Section 8.3.5.18, higher level findings (postclosure)).

8.3.1.8.1 Investigation: Studies to provide information required on direct releases resulting from volcanic activity

Purpose and objectives of the investigation

The purpose of this investigation is to provide the data required for an assessment of repository performance with respect to the possibility of direct releases resulting from volcanic events. The two performance parameters for this investigation have been identified by Issue 1.1. The two studies in this investigation will also supply the data required by Issue 1.8 (Section 8.3.5.17) to address the favorable and potentially adverse conditions of 10 CFR 60.122. Investigations 8.3.1.8.2 through 8.3.1.8.4 will also use the results of this investigation in their analyses of other intermediate performance measures.

8.3.1.8.1.1 Study: Probability of magmatic disruption of the repository

The purpose of this study is to assess the probability of disruption of a potential siting of a repository for storage of high level radioactive waste at Yucca Mountain by future volcanic activity. The probability assessment will be completed through a combination of studies and the results of these studies will be compared for consistency (Crowe et al., 1983a). The probability that volcanic activity could intersect the repository and/or erupt at the surface will be estimated from the analysis of a variety of data on the location and timing of volcanic events during the last 4 to 8 million yr, volcanic recurrence models, structural controls on the location of volcanic activity, and evaluation of the possible presence of magma bodies that could be the sources for future events.

8.3.1.8.1.1.1 Activity: Location and timing of volcanic events

Objectives

The objective of this activity is to synthesize the data collected by other activities on the age, location, eruptive history, and volume of late Cenozoic volcanic events in the region surrounding the site. These additional data will be used by Activity 8.3.1.8.1.1.4 to produce revised probability estimates of the disruption of the repository by volcanic events.

8.3.1.8.1.1.2 Activity: Evaluation of the structural controls of basaltic volcanic events

Objectives

This activity will investigate the time-space patterns of past basaltic volcanic activity in the Yucca Mountain region, the possible structural controls of volcanic centers, and the potential future sites of volcanic centers at and adjacent to Yucca Mountain. These data will be combined with alternative models of the tectonic setting of Yucca Mountain to bound the probability of repository disruption. Analog data from other volcanic fields will be evaluated to constrain structural models and to test the limited data base of volcanic centers in the Yucca Mountain Region.

8.3.1.8.1.1.3 Activity: Presence of magma bodies in the vicinity of the site

Objectives

The objective of this activity is to review geophysical and geochemical data collected in the vicinity of the site to assess whether there are any indications of the presence of crustal magma bodies that could be the source of future volcanic activity.

8.3.1.8.1.1.4 Activity: Probability calculations and assessment

Objectives

The objective of this activity is to revise the estimates of the probability of volcanic disruption of a repository site at Yucca Mountain (Crowe et al., 1982) incorporating newly acquired data on the age, location, eruptive history, and volume of volcanic centers in the Nevada Test Site (NTS) region, the results from activities investigating the possibility of structural controls of sites of volcanic activity and the presence of magma bodies in the Yucca Mountain area. The data for these events will be assembled to establish probability distributions which may be modified to reduce bias by the application of expert opinion.

8.3.1.8.1.2 Study: Physical processes of magmatism and effects on the repository

The purpose of this study is to gather data on the surface and subsurface effects of a potential volcanic eruption in a potential repository and the controlled area. The data will be used by Issue 1.1 and the other investigations in this program to assess the consequences of such an eruption on repository performance.

8.3.1.8.1.2.1 Activity: Eruptive Effects

Objectives

The objectives of this activity are to reevaluate previous studies of the physical processes of hydrovolcanic and Strombolian eruptions of basaltic magma. These studies will be used to define and describe potential eruption scenarios that assess the radiological consequences of magmatic disruption of the repository. Analog studies will be used to attempt to constrain the amount of waste carried to the surface from a repository that is disrupted by rising magma.

8.3.1.8.1.2.2 Activity: Subsurface effects of magmatic activity

Objectives

The objective of this activity are to evaluate the subsurface effects of emplacement of basalt dikes and intrusive bodies through and adjacent to a potential repository. This study will include an assessment of mechanisms of incorporation of waste in magma, the geometry of basalt intrusions, and coupled effects on waste isolation of basalt intrusions through or near a repository.

8.3.1.8.1.2.3 Magma system dynamics

Objectives

The objectives of this activity are to evaluate the dynamics of basaltic magmatism including tracing the processes of formation of basalt magma through generation in the mantle, ascent through the mantle and crust, potential storage in the mantle and crust, and eruption at the earth's surface. Physically- and mathematically-based models of basaltic processes will be developed as a framework for a process-based assessment of the effects of basaltic magmatic activity on a repository.

8.3.1.8.2 Investigation: Studies to provide information required on rupture of waste packages due to tectonic events

Purpose and objectives of the investigation

The purpose of this investigation is to provide the data necessary for an analysis and assessment of repository performance with respect to the possibility of tectonic processes and events affecting the lifetime of waste packages. The study and activities in this investigation will take data gathered by field studies in this and other programs and provide an analysis of the probability of the initiating events and their effects on waste package performance for use in assessing layout and design of the underground facilities.

This investigation will also provide data on the nature of tectonic processes operating at the site for use in analysis of favorable and potentially adverse conditions (NRC siting criteria).

There is also a need for data on the ground motion that would be expected during the waste package lifetime. This parameter and its related initiating event respond to the need identified in Issue 1.11 (Section 8.3.2.2, configuration of underground facilities (postclosure)) for such data. Issue 1.11 will use the ground motion data to evaluate the design of emplacement drifts and boreholes in order to assess their postclosure stability.

8.3.1.8.2.1 Study: Analysis of waste package rupture due to tectonic processes and events

The assessment of the probability and effects of all tectonic processes and events that could result in adverse effects on waste package lifetime are aggregated under this study.

8.3.1.8.2.1.1 Activity: Assessment of waste package rupture due to igneous intrusion

Objectives

The objective of this activity is to review and organize supporting field data collected by other activities, and to use this data to calculate the probability of an igneous intrusion penetrating the repository and the number of waste packages that would be affected by such an event.

8.3.1.8.2.1.2 Activity: Calculation of the number of waste packages intersected by a fault

Objectives

The objective of this activity is to collect and summarize the relevant data from other activities and calculate the number of waste packages that a fault penetrating the repository would intersect.

8.3.1.8.2.1.3 Activity: Probability and rate of faulting

Objectives

The objective of this activity is to summarize and evaluate the available data on slip rates and recurrence intervals on faults in and near the controlled area.

8.3.1.8.2.1.4 Activity: Assessment of waste package rupture due to faulting

Objectives

The objective of this activity is to complete an assessment of the probability of faulting in waste emplacement boreholes and effects of faulting on waste package lifetime.

8.3.1.8.2.1.5 Activity: Assessment of postclosure ground motion in the subsurface

Objectives

The objective of this activity is to provide an assessment of expected ground motion at the repository horizon in a 1,000-yr period.

8.3.1.8.2.1.6 Activity: Nature, age, and rate of folding and deformation in the repository horizon

Objectives

The objective of this activity is to provide an estimate of the rate of folding or deformation in the repository horizon during Quaternary time.

8.3.1.8.2.1.7 Activity: Assessment of waste package rupture due to folding and deformation

Objectives

The objective of this activity is to provide an assessment of the hazard resulting from folding and deformation to waste package integrity.

8.3.1.8.3 Investigation: Studies to provide information required on changes in unsaturated and saturated zone hydrology due to tectonic events

Purpose and objectives of the investigation

Issue 1.1 (Section 8.3.5.13) identifies and addresses the possibility that tectonic processes and events could produce the following changes in existing hydrologic conditions:

1. Alteration of average percolation flux over the repository.

2. Changes in WT elevation that affect the length of the unsaturated zone travel path or hydraulic gradients.

3. Alteration of rock hydrologic properties along significant travel paths.

The three studies in this investigation will provide assessments of the likelihood and magnitude of these hydrologic changes for use by Issue 1.1 in analyzing total system performance of the repository in limiting radionuclide releases to the accessible environment.

This investigation will also provide data on the nature of tectonic processes operating at the site for use in analysis of favorable and potentially adverse conditions (NRC siting criteria).

8.3.1.8.3.1 Study: Analysis of the effects of tectonic processes and events on average percolation flux rates over the repository

This study will produce analyses and assessments of the probability and effects of tectonic initiating events that may result in changes in the average percolation flux rate at the top of the TS welded unit.

8.3.1.8.3.1.1 Activity: Annual probability of volcanic or igneous events in the controlled area

Objectives

The objective of this activity is to calculate the annual probability of igneous and volcanic events within 0.5 km of the controlled area boundary.

8.3.1.8.3.1.2 Activity: Assessment of the effects of igneous intrusions and volcanic events on flux rates

Objectives

The objective of this activity is to produce an assessment of the possibility that volcanic or igneous events could cause significant changes in the average percolation flux rate at the top of the TS welded unit.

8.3.1.8.3.1.3 Activity: Faulting rates, recurrence intervals, and probable cumulative offset in 10,000 yr

Objectives

The objective of this activity is to provide estimates of the slip rates, recurrence intervals, and probable cumulative offset in 10,000 yr on Quaternary faults in and near the controlled area.

8.3.1.8.3.1.4 Activity: Effects of faulting on average flux rates

Objectives

The objective of this activity is to estimate the effects that the creation of scarps, the diversion of drainage, the change in the dip of beds, or the juxtaposition of beds due to fault offset would have on average percolation flux at the top of the TS welded unit.

8.3.1.8.3.1.5 Activity: Assessment of the effects of faulting on flux rates

Objectives

The objective of this activity is to provide an assessment of the probability that average percolation flux rates at the top of the TS welded unit at Yucca Mountain would be significantly affected by displacement due to future fault activity.

8.3.1.8.3.1.6 Activity: Uplift rates in the controlled area

Objectives

The objective of this activity is to calculate the rate of uplift or subsidence in and around the controlled area.

8.3.1.8.3.1.7 Activity: Assessment of the effects of folding, uplift, and subsidence on flux rates

Objectives

The objective of this activity is to assess the probability that folding, uplift, or subsidence will significantly alter average percolation flux rates at the top of the TS welded unit over the repository.

8.3.1.8.3.2 Study: Analysis of the effect of tectonic processes and events on changes in water-table elevation

This study will produce analyses and assessments of the probability that tectonic initiating events could result in significant changes in the elevation of the WT or potentiometric surface, changes in the hydraulic gradient, the creation of discharge points in the controlled area, or the creation of perched aquifers in the controlled area.

8.3.1.8.3.2.1 Activity: Thermal and barrier-to-flow effects of igneous intrusions on water-table elevation

Objectives

The objective of this activity is to model the effects that dikes or other intrusions would have on water-table elevation due either to the barrier to flow created by intrusion or the thermal pulse produced by the intrusion.

8.3.1.8.3.2.2 Activity: Assessment of the effects of igneous intrusions on water-table elevations

Objectives

The objective of this activity is to produce an assessment of the probability that igneous intrusions will cause 1) significant changes in the elevation of the WT or potentiometric surface, 2) changes in the hydraulic gradient, 3) the creation of discharge points in the controlled area, or 4) the creation of perched aquifers in the controlled area.

8.3.1.8.3.2.3 Activity: Assessment of the effect of strain changes on water-table elevation

Objectives

The objective of this activity is to estimate the probability that changes in stress or strain resulting from faulting events could significantly alter water-table levels or potentiometric surfaces in and around the controlled area.

8.3.1.8.3.2.4 Activity: Assessment of the effect of folding, uplift, or subsidence on water-table elevation

Objectives

The objective of this activity is to provide an assessment of the probability that folding, uplift, or subsidence could change the elevation of the repository with respect to the level of the WT sufficiently to significantly alter the length of the unsaturated zone travel path.

8.3.1.8.3.2.5 Activity: Effects of faulting on water-table elevation

Objectives

The objective of this activity is to produce models to analyze the potential for fault offset to change the elevation of the WT or potentiometric surface, change the hydraulic gradient, create discharge points in the controlled area, or create perched aquifers in the controlled area.

8.3.1.8.3.2.6 Activity: Assessment of the effect of faulting on water-table elevation

Objectives

The objective of this activity is to prepare an assessment of the probability that fault offset will result in significant changes in the elevation of the WT or potentiometric surface, changes in the hydraulic gradient, the creation of discharge points in the controlled area, the creation of perched aquifers in the controlled area in 10,000 yr.

8.3.1.8.3.3 Study: Analysis of the effects of tectonic processes and events on local fracture permeability and effective porosity

The activities in this study address tectonic initiating events and processes that could cause local changes in saturated fracture permeability or fracture effective porosity.

8.3.1.8.3.3.1 Activity: Assessment of the effects of igneous intrusions on local fracture permeability and effective porosities

Objectives

The objective of this activity is to assess the possibility that igneous intrusions, such as dikes or sills, could cause changes in the hydrologic flow properties of the surrounding rocks.

8.3.1.8.3.3.2 Activity: Assessment of the effects of faulting on local fracture permeability and effective porosities

Objectives

The objective of this activity is to assess the probability that movement on faults could result in significant local changes in saturated fracture permeability and fracture effective porosity along the fault that could affect the regional ground water flow system.

8.3.1.8.3.3.3 Activity: Assessment of the effects of stress or strain on hydrologic properties of the rock mass

Objectives

The objective of this activity is to assess the probability that changes in stress or strain conditions around the site caused by a tectonic event could result in significant changes in the saturated fracture permeability and fracture effective porosity of the rock mass.

8.3.1.8.4 Investigation: Studies to provide information required on changes in rock geochemical properties resulting from tectonic processes

Purpose and objectives of the investigation

Issue 1.1 (Section 8.3.5.13, total system performance), addresses the possibility that tectonic processes and events could produce significant changes in the geochemical properties of the rocks of the controlled area that control the rate of radionuclide movement. The study and activities in this investigation will address these requirements by providing assessments of the probability that the tectonic initiating events that have been recognized by Issue 1.1 could significantly alter distribution

coefficients. These results will be used by Issue 1.1 to analyze total system performance of the repository in limiting radionuclide releases to the accessible environment. It is anticipated that the data to be gathered in the geochemistry program (Section 8.3.1.3) to address other concerns will provide the data necessary to evaluate the rate of geochemical change. The level of effort for the activities related to these initiating events is therefore anticipated to be low and to consist primarily of organizing and presenting the data collected in other programs to provide the basis for evaluating the credibility of the initiating events in performance assessment activities.

This investigation will also provide data on the nature of tectonic processes operating at the site for use in its analysis of favorable and potentially adverse conditions (NRC siting criteria).

8.3.1.8.4.1 Study: Analysis of the effects of tectonic processes and events on rock geochemical properties

The activities in this study provide assessments of the initiating events related to local changes in distribution coefficients resulting from tectonic processes and events.

8.3.1.8.4.1.1 Activity: Assessment of the change in rock geochemical properties due to igneous intrusions

Objectives

The objective of this activity is to assess the probability that igneous intrusions will cause significant changes in local distribution coefficients in the controlled area in 10,000 yr.

8.3.1.8.4.1.2 Activity: Assessment of the degree of mineral change along fault zones in 10,000 yr

Objectives

The objective of this activity is to assess the probability that local distribution coefficients will be significantly altered along faults in 10,000 yr by displacement events.

8.3.1.8.4.1.3 Activity: Assessment of the effects of fault offset on travel pathway

Objectives

The objective of this activity is to assess the possibility that offsets occurring on faults in 10,000 yr in the controlled area will divert radionuclides to travel pathways with significantly different distribution coefficients or water chemistry.

8.3.1.8.4.1.4 Activity: Assessment of the degree of mineral change in the controlled area resulting from tectonically induced change in water-table elevations

Objectives

The objective of this activity is to assess the probability and nature of tectonically induced changes in water-table level that might result in significant mineral changes in the newly saturated or unsaturated rock.

8.3.1.8.5 Investigation: Studies to provide the information required by the analysis and assessment investigations of the tectonics program

Purpose and objectives of the investigation

The studies and activities in this investigation will collect the field data called for by the analysis and assessment activities in Investigations 8.3.1.8.1 through 8.3.1.8.4. Because most of the data required by these analysis and assessment activities are being collected by other programs, the activities in this investigation are limited to a small number providing data to support the analysis of volcanic, igneous intrusion, and folding processes.

8.3.1.8.5.1 Study: Characterization of volcanic features

The activities under this study will provide refined data on the age, location, eruptive models, and volume of young volcanic rocks in the vicinity of the site. These data will be used to refine the calculations on the probability of igneous or volcanic events occurring in the controlled area and penetrating the repository. Much of the work for this study has been completed. The focus of this study is to obtain data from continuing activities that are necessary to complete risk assessment.

These data will be used in Activity 8.3.1.8.1.1.2 to assess the significance of petrologic patterns of the Crater Flat volcanic field and to examine time-space-volume-compositional patterns of evolution of basaltic volcanic fields.

8.3.1.8.5.1.1 Activity: Volcanism drillholes

Objectives

The objective of this activity is to investigate the origin of four or five aeromagnetic anomalies found in Crater Flat and the Amargosa Valley. These anomalies may represent shallowly buried basaltic or silicic volcanic centers or intrusive bodies. The anomaly sites will be drilled and continuous core recovered from the drillholes. Data from this work will be used to refine probability calculations, to evaluate the tectonic setting of volcanic centers, and to test concepts of the temporal geochemical patterns of basalts in the NTS region.

8.3.1.8.5.1.2 Activity: Geochronology studies

Objectives

The objective of this activity is to establish the chronology of basaltic volcanism and the youngest silicic volcanic activity in the Yucca Mountain region. These data will be used to revise the recurrence rate of the volcanic probability calculations and to determine the age of cessation of silicic volcanic activity. The geochronology studies have been under way for a number of years and the chronology of older basaltic activity (> 8 million yr) has been established. Further studies are required for three topics:

1. The age of Quaternary volcanic events in the Yucca Mountain region.

2. The age and eruption chronology of the youngest (< 0.5 ma) volcanic event in the Yucca Mountain area.

3. The age of the youngest silicic volcanic activity in the region with emphasis on the Black Mountain caldera or young silicic rocks that may be encountered in shallow volcanic drillholes.

8.3.1.8.5.1.3 Activity: Field geologic studies

Objectives

The objective of this activity is to establish the field geologic relations and the eruptive history of basaltic volcanic centers in the Yucca Mountain region. Most of the work is completed, including reconnaissance mapping of older volcanic centers (>6 million yr) and detailed mapping of younger volcanic centers. Two problems remain:

1. Recently acquired geochronology data have shown that some small volume basalt centers may be polycyclic (i.e., formed during multiple cycles of volcanic activity separated by significant intervals of inactivity). Further geologic mapping coupled with geochronology studies are required to investigate how common polycyclic activity is at the young (<4.0 million yr) volcanic centers of the Yucca Mountain region.

2. Field studies are needed to attempt to correlate scoria sequences exposed in alluvial deposits in trenches with the scoria cone deposits in the Crater Flat area.

8.3.1.8.5.1.4 Activity: Geochemistry of scoria sequences

Objectives

The objective of this activity is to determine the geochemistry of scoria sequences of different ages at the Lathrop Wells center and older centers in the Crater Flat area. These data will be used to test and develop petrologic models of polycyclic volcanism. The models will be used to test geologic assumptions made for 1) the probability calculations and 2) the time-space tectonic model for the

distribution of basaltic volcanism developed from Activity 8.3.1.8.1.1.2. In addition, the data on the geochemistry of the scoria sequences will also be used to correlate basaltic ash interbedded in trenches with their correct eruptive source.

8.3.1.8.5.1.5 Activity: Geochemical cycles of basaltic volcanic fields

Objectives

The objective of this activity is to determine the time-space geochemical variations of the volcanic fields of the southern Great Basin.

These patterns will be compared with the documented geochemical patterns for the volcanic fields of the Yucca Mountain area. This information will be used to test a model that associates changes in basalt composition, increases in the eruptive frequency of polycyclic eruptions, and decreases in the volume of eruptive activity with the waning or termination stages of basaltic volcanic fields. This model, if valid, supports the idea that the Yucca Mountain area has passed the peak of maximum basaltic volcanic activity. Probability calculations, which are based on the peak rate of activity, could therefore be shown to be a worst-case approach to volcanic risk assessment.

8.3.1.8.5.2 Study: Characterization of igneous intrusive features

The activities in this study will gather data concerning the presence of thermal anomalies in the area and data on the geochemical and physical effects of intrusions on the surrounding rock. The evidence for the presence or absence of thermal anomalies will be used as part of the evaluation of the presence of significant magma bodies in the area and their relation to the probability of future volcanic events. The data on the effects of intrusions on surrounding rocks will be used as part of the assessments of the probability of significant changes on local fracture permeabilities and local effective porosities (Study 8.3.1.8.3.3) and local distribution coefficients (Study 8.3.1.8.4.1).

8.3.1.8.5.2.1 Activity: Evaluation of depth of curie temperature isotherm

Objectives

The objective of this activity is to determine the depth of the curie temperature isotherm by analyses of existing magnetic survey data.

8.3.1.8.5.2.2 Activity: Chemical and physical changes around dikes

Objectives

The objective of this activity is to gather data on the nature and extent of chemical and physical changes that may occur in the surrounding tuffs as a result of the intrusion of dikes or sills.

8.3.1.8.5.2.3 Activity: Heat flow at Yucca Mountain and evaluation of regional ambient heat flow and local heat flow anomalies

Objectives

The objectives of this activity are to

1. Compile available heat flow data at and near Yucca Mountain and identify local heat flow anomalies in conjunction with Activity 8.3.1.9.2.1.3. The quality of these data will be assessed under this activity (8.3.1.8.5.2.3) in conjunction with Activity 8.3.1.9.2.1.3.

2. Compile available calcite and silicate geothermometry data from calcite and silica deposits in soils and core and along faults in the vicinity of Yucca Mountain. These data will be assessed with respect to their utility for measuring thermal and hydrothermal perturbation associated with Quaternary volcanism, such as that at the Lathrop Wells volcanic center. In addition, the utility of such data for calibrating and evaluating theoretical calculations of the thermal and hydrothermal effects of volcanism will be assessed.

3. Assess the potential value of additional heat flow and other geothermometry studies for satisfying YMP goals. Recommendations will be made as to the objectives, nature and scope of any additional studies that may be needed, including the collection of geothermal data from existing or planned drillholes or specific methods of drill hole construction necessary to collect the highest quality heat flow data.

8.3.1.8.5.3 Study: Investigation of folds in Miocene and younger rocks of region

The objective of this study is to establish the regional pattern and rate of Neogene folding. The parameters TBD are distribution, amplitude, and age of folds.

8.3.1.8.5.3.1 Activity: Evaluation of folds in Neogene rocks of the region

Objectives

The objective of this activity is to establish the pattern, rate, amplitude, and wavelength of post-middle-Miocene folding in the region.

8.3.1.9 The human interference program

Summary of performance and design requirements for human interference information

The postclosure human interference test program addresses 1) the likelihood of inadvertent human intrusion into a mined geologic disposal system (MGDS), 2) interference with long-term MGDS performance due to human activities, and 3) the possible consequences of such interference events.

The performance and design requirements for the human interference program directly reflect the regulatory requirements of the NRC, the EPA, and the DOE. These requirements, and their relationships to the human activities program can be summarized as follows:

1. Issue 1.1 (total system performance, Section 8.3.5.13) requires information that can help in estimating the probability of human intrusion and interference during the postclosure period.

2. Issue 1.8 (NRC siting criteria, Section 8.3.5.17) addresses NRC regulations 10 CFR 60.21(c)(13), 60.122(a), 60.122(c)(2), and 60.122(c)(17) requiring that resources at the site with current markets be identified, and described in terms of net and gross values. Resources that occur in abundances that may be marketable in the future must also be identified and described. A complete assessment of the potential consequences of exploration activities (e.g., drilling) or resource extraction that could realistically influence the ability of the MGDS to isolate waste during the postclosure period, is required.

3. Issue 1.9 (higher level findings - postclosure system and technical guidelines, Section 8.3.5.18) is the evaluation of the site against the qualifying and disqualifying conditions of the DOE siting guidelines. For the site to be considered for selection as the first repository, it must be demonstrated that the site is located in an area such that natural resources at or near the site are not likely to give rise to interference activities.

4. Issue 4.4 (preclosure design and technical feasibility, Section 8.3.2.5) requires site-specific data for the design and placement of the permanent warning system.

8.3.1.9.1 Investigation: Studies to provide the information required on natural phenomena and human activities that might degrade surface markers and monuments

Purpose and objectives of the investigation

The purpose of Investigation 8.3.1.9.1 is to obtain the site-specific information on the occurrence and consequences of natural phenomena needed to satisfy the parameter requests of the performance and design issues. The objective of the investigation is to compile and evaluate these data so that they can provide information directly to the performance and design issues.

8.3.1.9.1.1 Study: An evaluation of natural processes that could affect the long-term survivability of the surface marker system at Yucca Mountain

This study provides information on the currently or potentially active natural processes at Yucca Mountain capable of adversely affecting the long-term survivability of the surface marker system. This study will be a synthesis of data obtained from other activities to be undertaken in support of several investigations. The data will then be evaluated to determine the most suitable locations of the monuments for the surface marker system. Input for this study will be provided by Investigations 8.3.1.6.2, 8.3.1.6.3, 8.3.1.8.1, and 8.3.1.8.2.

8.3.1.9.1.1.1 Activity: Synthesis of tectonic, seismic, and volcanic hazards data from other site characterization activities

Objectives

The objective of this activity is to identify the potential locations of faulting and volcanic eruption or intrusion that could occur where they could affect the marker system.

8.3.1.9.1.1.2 Activity: Synthesis evaluation of the effects of future erosion and deposition on the survivability of the marker system at Yucca Mountain

Objectives

The objective of this activity is to determine the effects of future erosion and deposition on the topographic elements of the controlled area boundary at Yucca Mountain. This information will be evaluated to identify the optimum locations for the markers.

8.3.1.9.2 Investigation: Studies to provide the information required on present and future value of energy, mineral, land, and ground-water resources

Purpose and objectives of the investigation

The natural resource potential of a candidate site for an MGDS is an important consideration in evaluating the likelihood for inadvertent human intrusion and interference. The presence of natural resources or an environment that is favorable for the occurrence of natural resources could lead to prospecting exploration within or near the controlled area, and possible subsequent resource exploitation. The exploration or extraction of resources could result in direct releases of radionuclides to the accessible environment or could modify the hydrologic, geochemical, and rock characteristics at the site (Investigation 8.3.1.9.3) by possibly shortening travel paths to the accessible environment. Thus, a complete evaluation of the natural resource potential of the Yucca Mountain site is essential in determining the likelihood for inadvertent human intrusion and interference.

8.3.1.9.2.1 Study: Natural resource assessment of Yucca Mountain, Nye County, Nevada

This study will identify and assess the natural resource potential at the proposed repository site at Yucca Mountain. Mineral and energy resources (including hydrocarbon and geothermal resources) will be included. The information and data obtained in this study will provide the basis for probabilistic calculations for determining the likelihood of inadvertent human interference and intrusion (Study 8.3.1.9.3.1).

8.3.1.9.2.1.1 Activity: Geochemical assessment of Yucca Mountain in relation to the potential for mineralization

Objectives

The overall objective of this activity is to conduct a geochemical sampling program to evaluate the potential for precious, base, and strategic metals; energy resources; and industrial mineral resources in the vicinity of Yucca Mountain. Specific objectives include:

1. Selecting a suite of elements for analysis in a geochemical sampling program. The suite will be based upon known commodities that occur in silicic tuffs and/or trace elements indicative of commodities that occur in the tuffs.

2. Developing a field program to include a systematic and unbiased sampling of surface materials. Using existing core, core obtained during site characterization, and other subsurface samples to evaluate the potential of mineralization at and near the site. This includes evaluation of deposits that occur along faults within breccia zones and deposits that may be hidden by alluvium.

3. Generating a first-order geochemical data base for selected elements obtained from surface and subsurface sampling within the vicinity of Yucca Mountain.

4. Evaluating the data base in conjunction with geological and geophysical data obtained from other site characterization activities to determine if additional data are needed for an evaluation of natural resources.

5. Evaluating the potential for the occurrence of natural resources in the vicinity of Yucca Mountain based on an analysis of the geochemical data. These data will be examined and evaluated statistically from anomaly and residual maps, and by comparison with calculated background levels and average elemental values found in silicic tuffs.

8.3.1.9.2.1.2 Activity: Geophysical/geologic appraisal of the site relative to mineral resources

Objectives

This activity will qualitatively evaluate the available geophysical data base as it relates to Study 8.3.1.9.2.1. The existing geophysical data base (Section 1.7.1.1) will be examined to define any geophysical anomalies that may require additional exploration and possibly constrain any known geochemical anomalies (Activity 8.3.1.9.2.1.1). The geophysical data base will also be used as a basis for comparisons to analog environments of known mineralization (Activity 8.3.1.9.2.1.5). Geologic models derived from geophysical data in Section 8.3.1.17 will be evaluated for their impact on mineral resources. Further work may be planned depending on the results of studies described in Section 8.3.1.17.4 and the qualitative evaluation performed in this activity.

8.3.1.9.2.1.3 Activity: Assessment of the potential for geothermal energy at Yucca Mountain, Nevada

This activity will be undertaken in cooperation with Activity 8.3.1.8.5.2.3 (evaluation of regional ambient heat flow and local heat flow anomalies). Both activities are aimed at characterizing the local geothermal regime as it might relate to repository performance during the postclosure period. Activity 8.3.1.8.5.2.3 will focus on geothermal activity and heat flow calculations as they could relate to Quaternary igneous processes or events. This activity (8.3.1.9.2.1.3) assesses the geothermal regime in terms of its energy resource potential for either hydrothermal or conductive reservoir thermal systems (Section 1.7.1.5.2). Data compilation and evaluation will be done jointly through both activities.

Objectives

The overall objective of this activity is to assess the potential for a geothermal energy resource at Yucca Mountain, Nevada.

The objectives of this activity are to

1. Compile measured geothermal and calculated heat flow data at and in Yucca Mountain and vicinity to quantify vertical and horizontal geothermal gradients. The quality of these data will be assessed under this activity in conjunction and cooperation with Activity 8.3.1.8.5.2.3. Temperature and other data collected under site unsaturated zone hydrology (Section 8.3.1.2.2) and site saturated zone hydrology (Section 8.3.1.2.3) will be assessed here and in cooperation with Activity 8.3.1.8.5.2.3.

2. Compile appropriate chemical and isotopic (oxygen and deuterium) analyses of water samples from springs and wells useful for predicting subsurface temperatures. These data will be useful in comparing subsurface temperatures at the site with measured temperature profiles and heat flow data for the region.

3. Evaluate the existing data on geothermometry and heat flow necessary to adequately characterize the region for its geothermal resource potential.

4. Recommend whether additional studies may be needed, including the collection and integration of additional geothermal data from existing or planned drillholes.

5. Provide the information necessary for the final resource assessment to be performed in Activity 8.3.1.9.2.1.5.

8.3.1.9.2.1.4 Activity: Assessment of hydrocarbon resources at and near the site

Objectives

The objectives of this activity are to

1. Determine the potential for the presence or absence of suitable source rocks, reservoir rocks, and traps and seals at and near the site.

2. Determine the potential for occurrence of conventional hydrocarbon resources (crude oil and natural gas) at and near the site. This will include a review and assessment of drillholes emplaced for oil and gas exploration within the geographic area of the site. The radius of this area is expected to be on the order of tens of kilometers, but its size will depend largely on the results of the work described previously.

3. Provide necessary data for the overall mineral and energy resource assessment to be performed in Activity 8.3.1.9.2.1.5.

8.3.1.9.2.1.5 Activity: Mineral and energy assessment of the site, comparison to known mineralized areas, and the potential for undiscovered resources and future exploration

Objectives

The objective of this activity is to integrate the data and information collected from Activities 8.3.1.9.2.1.1 (geochemical assessment), 8.3.1.9.2.1.2 (geophysical/geologic assessment), 8.3.1.9.2.1.3 (geothermal energy assessment), and 8.3.1.9.2.1.4 (hydrocarbon assessment). Integration of these activities and the data acquired from them will allow:

1. The identification of mineral resources with current markets, as well as the calculation of gross and net values for identified resources or reserves.

2. The physical description of mineral resources with potential future markets relative to "tonnage, or other amount, grade, and quality," as described in 10 CFR 60.21(c)(13).

3. The physical description of energy resources using appropriate parameters that describe the extent and magnitude of those resources.

4. The evaluation of the resource potential of any identified or undiscovered mineral and energy resources, based upon a "representative" area of "similar size" and a comparison to the Yucca Mountain site (10 CFR 60.122(c)(17)).

5. An estimation of the potential for undiscovered deposits of those resources described in 10 CFR 60.21(c)(13). This will be accomplished using site-specific data in conjunction with evaluation of models found in the literature of economic mineralization, hydrocarbon generation and entrapping processes, and extraction-conversion methods in geothermal energy utilization.

This activity provides data necessary for the probabilistic calculations for determining the potential for future inadvertent human interference or intrusion (Study 8.3.1.9.3.2).

8.3.1.9.2.2 Study: Water resource assessment of Yucca Mountain, Nevada

Ground water is expected to be the primary mechanism by which radionuclides might be transported from the repository to the accessible environment. Ground water is the sole source of supply for residents, irrigated agriculture, and industry within the geohydrologic study area. Changes

in population, economic and industrial development, and consumptive uses of water will affect ground-water depths and withdrawal rates. Future ground-water withdrawals could affect ground-water flow within the geohydrologic system. This study consists of a single activity that will use available data to estimate the future supply, demand, and value of the ground-water resource in southern Nevada, proximal to Yucca Mountain.

8.3.1.9.2.2.1 Activity: Projected trends in local and regional ground-water development, and estimated withdrawal rates in southern Nevada, proximal to Yucca Mountain

Objectives

The objectives of this activity are to 1) assess the current and projected supply and demand situation for ground water in the geohydrologic study area, and 2) estimate the value of the ground-water resource.

8.3.1.9.3 Investigation: Studies to provide the information required on potential effects of exploiting natural resources on hydrologic, geochemical, and rock characteristics

Purpose and objectives of the investigation

The purpose of this investigation is to obtain the information that will be used to satisfy the parameter requests made in Issue 1.1 (total system performance). Two types of data are requested in this performance issue: 1) information on the resources presently at the site that would influence the likelihood of exploratory drilling within the controlled area, and 2) the potential effects of resource extraction on the hydrologic, geochemical, and rock characteristics at the site. The first objective of this investigation is to evaluate the data relative to the resource potential at the site, resource extraction, and marker system survivability necessary to determine the probability range for exploratory drilling. The second objective is to assess the potential effects of resource extraction for all commodities known to be present or inferred to be present at the site. Thus, this investigation will compile all the site data generated by the human interference program and pass the required parameters to Issue 1.1 (total system performance, Section 8.3.5.13).

8.3.1.9.3.1 **Study: 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**

In this study, data will be compiled and analyzed for assessing the likelihood of inadvertent human interference in the vicinity of Yucca Mountain.

8.3.1.9.3.1.1 Activity: Compilation of data to support the assessment calculation of the potential for inadvertent human intrusion at Yucca Mountain

Objectives

The objectives of this activity are to

1. Determine the maximum drilling density and frequency (drillholes per square kilometer per 10,000 yr) that can be reasonably assumed for a repository at Yucca Mountain.

2. Determine the extent to which future ground-water withdrawals will modify the expected ground-water flow paths.

8.3.1.9.3.2 Study: An evaluation of the potential effects of exploration for, or extraction of, natural resources on the hydrologic characteristics at Yucca Mountain

This study will assess in qualitative or quantitative terms, the effects of exploiting natural resources known or believed to be present at Yucca Mountain. Consideration of the effects of resource exploitation or extraction are limited to changes in the hydrologic, geochemical, and rock characteristics.

8.3.1.9.3.2.1 Activity: An analysis of the potential effects of future ground-water withdrawals on the hydrologic system in the vicinity of Yucca Mountain, Nevada

Objectives

The objective of this activity is to determine the potential effects of future ground-water withdrawals on the hydrologic system at Yucca Mountain. Effects of the withdrawals will be defined qualitatively and quantitatively.

8.3.1.9.3.2.2 Activity: Assessment of initiating events related to human interference that are considered not to be sufficiently credible or significant to warrant further investigation

Objectives

The objective of this activity is to determine whether those initiating events that have been identified for the human interference issue are sufficiently credible or significant to necessitate additional investigation. This will be documented in a topical report.

8.3.1.10 Objectives of population density and distribution program

This section presents references and information to support resolution of performance and design issues related to preclosure radiological safety. These requirements are derived from 10 CFR Part 20, 10 CFR Part 60, 40 CFR Part 191 and DOE orders. The detailed link to these regulations is presented in the performance and design issues that require data from the population density and distribution program.

Collection of population density and distribution data is not considered a site characterization activity as defined in the Nuclear Waste Policy Act (NWPA, 1983). Therefore, the format and details for data collection will not be presented in this document. The details of the methodology to be used in analyzing the population related information will be discussed in the Radiological Monitoring Plan. The methods and procedures for collection of population data will be part of the YMP socioeconomic planning process and environmental program planning effort.

8.3.1.11 Objectives of land ownership and mineral rights program

The land ownership and mineral rights program derives from the requirements of 10 CFR Part 960 and 10 CFR Part 60. The provisions of 10 CFR 60.121 require that

> Both the geologic repository operations area and the controlled area shall be located in and on lands that are either acquired lands under the jurisdiction and control of DOE, or lands permanently withdrawn and reserved for its use.

This provision further requires that 1) such lands shall be held free and clear of all encumbrances, 2) the DOE shall exercise any jurisdiction and control over surface and subsurface estates necessary to prevent adverse human actions that could significantly reduce the repository's ability to achieve isolation, and 3) the DOE shall also have obtained water rights as may be needed to satisfy the requirements of the repository operations area.

The plans and procedures for acquiring land ownership and mineral rights are not considered site characterization activities as defined by the NWPA (NWPA, 1983).

8.3.1.12 Objectives of the meteorology program

Summary of performance and design requirements for meteorological information

The purpose of the meteorological program is to provide data required for resolving of performance and design issues. The types of data requested fall into three categories: 1) data needed in calculating radiological doses resulting from airborne releases from the repository during the pre-closure operational period; 2) information required for design of surface facilities; and 3) hydrometeorological measurements for hydrologic and climatic studies.

8.3.1.12.1 Investigation: Studies to provide data on regional meteorological conditions

Purpose and objectives of the investigation

The purpose of this investigation is to provide data on the regional meteorological conditions in the general vicinity of Yucca Mountain, extending to Las Vegas, and to coordinate meteorology program monitoring efforts with other YMP meteorological monitoring. Some of the data can then be used in calculating radiation doses to the general public and at the nearest major population center that might be caused by the proposed repository under routine and accident scenarios.

8.3.1.12.1.1 Study: Characterization of the regional meteorological conditions

Objectives

The objective of this study is to gather and analyze meteorological data from various locations to characterize the regional meteorology and assimilate that information into a regional summary report. This will be accomplished by determining if there are meteorological monitoring stations that have been operated in the general vicinity of the site and might be sources of information (in addition to those evaluated in Section 5.1). Comparisons between site and very-near-site data and data from these regional sources will give a more complete picture of the areal variability of conditions around the site than is presently available. This characterization will provide a regional overview of wind flow patterns and other meteorological parameters (related to atmospheric dispersion) associated with those patterns in and around Yucca Mountain.

8.3.1.12.1.2 Study: Plan for synthesis of Yucca Mountain Site Characterization Project meteorological monitoring

Objectives

The objective of this study is to develop a plan that provides for coordination of meteorological monitoring efforts proposed during site characterization by the various YMP participants.

8.3.1.12.2 Investigation: Studies to provide data on atmospheric and meteorological phenomena at potential locations of surface facilities

Purpose and objectives of the investigation

The purpose of this investigation is to collect site-specific meteorological data that can be used in calculating doses to workers, including workers in restricted areas, and the general public under routine and accident scenarios.

8.3.1.12.2.1 Study: Meteorological data collection at the Yucca Mountain site

The purpose of conducting meteorological monitoring at Yucca Mountain is to provide data that can be used in resolving design and performance issues associated with preclosure radiological safety.

8.3.1.12.2.1.1 Activity: Site meteorological monitoring program

Objectives

The objective of the site monitoring program is to collect meteorological data at potential locations of surface facilities and at a sufficient number of additional locations deemed necessary to characterize the wind flow patterns in the vicinity of Yucca Mountain.

These data must be suitable for use in dispersion models that will be used in assessing radiological impacts resulting from repository operations. Discussion on the use and applicability of the output of these dispersion models is presented under Information Need 2.7.1 (Section 8.3.2.3.1). Another objective of the site monitoring program, although not related to resolution of this information need, is to provide data that are suitable for permitting and licensing activities for both site characterization and repository development.

8.3.1.12.2.1.2 Activity: Data summary for input to dose assessments

Objectives

The objective of this activity is to process the meteorological data collected as a result of Activity 8.3.1.12.2.1.1 into a format and content that will be useful in assessing radiological impacts, as required by the design and performance issues.

8.3.1.12.3 Investigation: Studies to provide data on the location of population centers relative to wind patterns in the general region of the site

Purpose and objectives of the investigation

The purpose of this investigation, similar to Investigation 8.3.1.12.1, is to provide data on wind flow patterns in the general region of Yucca Mountain. These data will then be used in estimating doses to the public and in doing so ensure that wind flow patterns would not preferentially transport material towards population centers.

8.3.1.12.4 Investigation: Studies to provide data on potential extreme weather phenomena and their recurrence intervals

Purpose and objectives of investigation

The purpose of this investigation is to assimilate data that can be used in evaluating the impact of extreme weather phenomena on surface facilities.

8.3.1.12.4.1 Study: Characterize the potential extreme weather phenomena and their recurrence intervals

Objectives

The objective of this study will be to evaluate the existing historical meteorological and climatological records, technical publications, and other relevant information to quantify the extreme weather phenomena that may be expected at the Yucca Mountain site and determine their recurrence interval.

8.3.1.13 Objectives of offsite installations and operations program

Summary of performance and design requirements for offsite installations and operations information

This program provides the technical data required to support the resolution of the following performance and design issues:

Performance or design issue	Short title	SCP section
2.1	Radiological exposures to public--normal conditions	8.3.5.3
2.2	Worker radiological safety--normal conditions	8.3.5.4
2.3	Accidental radiological releases	8.3.5.5
2.5	Higher level finding--preclosure radiological safety	8.3.5.6
2.7	Repository design criteria for radiological safety	8.3.2.3

Approach to satisfy performance and design requirements

The data base presented in the environmental assessment (DOE, 1986b) describes the nearby offsite installations and operations that could potentially affect repository operations. Further information required to support resolution of design and performance issues related to radiological safety includes the following:

1. An evaluation of offsite accident initiators, their probabilities and potential impacts to support Issues 2.3 and 2.5.

2. An assessment of routine releases from nuclear operations to support Issues 2.1, 2.2, and 2.5.

3. An assessment of the onsite impact of nonrepository-related routine and potential accidental releases of radioactive material to support Item 1 and to support resolution of Issues 2.3 and 2.5.

4. The collection of agricultural and cultural data to support the calculation of the dose to the public from releases at the Yucca Mountain site and to support resolution of Issues 2.1 and 2.3.

8.3.1.13.1 Investigation: Determination of nearby industrial, transportation, and military installations and operations (nuclear and nonnuclear)

Purpose and objectives of the investigation

The data and parameters list includes those items considered important to assess impacts from nearby DOE, industrial, transportation, and military operations. These parameters will be included in performance strategies as presented in the performance and design issues and ultimately used to address preclosure radiological safety aspects of the site.

8.3.1.13.1.1 Activity: Identify near-site activities

Objectives

The objective of this activity is to identify and describe all DOE, industrial, commercial, transportation, and military operations within 8 km of the Yucca Mountain site. In addition, significant operations outside this area that could impact the site will also be evaluated. This will not include offsite radioactive materials transportation since this operation will be addressed by the Division of Systems Integration and the environmental program planning efforts of the YMP. For the environmental impact statement, offsite transportation will be considered in evaluating the impact of the repository facility.

8.3.1.13.1.2 Activity: Characterize nuclear fuel cycle facilities in the area

Objectives

The objective of this activity is to identify all nuclear fuel cycle facilities within 80 km of the Yucca Mountain site or within Nevada areas adjacent to Las Vegas.

8.3.1.13.1.3 Activity: Characterize all nuclear facilities not associated with the nuclear fuel cycle near the Yucca Mountain site

Objectives

The objective of this activity is to characterize the impacts of all radiological operations at facilities within 80 km of the Yucca Mountain site that are not part of the nuclear fuel cycle. The basis for using an 80 km radius for this activity is documented in Section 4.3.2 of the radiological monitoring plan. Because of the potential for classified information being associated with the identification of NTS operations, radionuclide concentrations in the existing environment of the Yucca Mountain area will be assumed to bound the cumulative effects of past radiological operations in the area. Attempts will be made to make corrections for global fallout and natural sources.

8.3.1.13.2 Investigation: Potential impacts of nearby installations and operations

Purpose and objectives of investigation

The information collected from Investigation 8.3.1.13.1 will be used to conduct impact assessments as a result of accidents involving any nearby installations and operations. Those accidents include radiological and nonradiological events that may have an impact on site operations. The information collected will also be used to assess compliance with 40 CFR 191.03 and to resolve Issue 2.5 (Section 8.3.5.6) for routine releases, which addresses compliance with 40 CFR 191.03, 10 CFR Part 20, and 10 CFR Part 60. The results of these assessments will provide data and analyses for use in determining the preclosure radiological safety aspects of the site as outlined in the performance and designs issues of Key Issue 2 (preclosure radiological safety).

8.3.1.13.2.1 Activity: Evaluate near-site activities

Objectives

The objective of this activity is to review all commercial, DOE, Department of Defense, and transportation operations within 8km of the site; identify those operations that could act as accident initiators; and quantify their probability and magnitude. This activity will reduce the list of activities gathered in Activity 8.3.1.13.1.1 to those that could act as accident initiators, thus generating accident scenarios for analysis in the resolution of Issues 2.3 and 2.5.

8.3.1.13.2.2 Activity: Evaluation of the impact of nuclear fuel cycle operations near the Yucca Mountain site and Las Vegas

Objectives

The objective of this activity is to project the impact of all nuclear fuel cycle operations within 80 km of the Yucca Mountain site.

8.3.1.13.2.3 Activity: Evaluate the impact of all nuclear facilities not associated with the nuclear fuel cycle near the Yucca Mountain site

Objectives

The objective of this activity is to use the data from Activity 8.3.1.13.1.3 to project airborne concentrations. The probability of such concentrations resulting from operations within 80 km of the Yucca Mountain site will then be estimated and used to predict the potential for exposure of individuals in Las Vegas, Nevada.

8.3.1.13.2.4 Activity: Evaluate the impact of ground motion from nuclear testing activities at the Nevada Test Site

This activity is addressed in the resolution of Investigation 8.3.1.17.3.

8.3.1.14 Objectives of overview of the surface and subsurface access characteristics program

Summary of performance and design requirements for surface and subsurface access characteristics information

The surface characteristics and subsurface access program reflects requirements from the DOE, the NRC, and the EPA that the surface facilities and subsurface access facilities (ramps and shafts) must ensure public health and safety, are technically feasible, and have reasonable costs. This program investigates two areas pertinent to preclosure design and performance issues:

1. Topography (Investigation 8.3.1.14.1).
2. Soil and rock conditions (Investigation 8.3.1.14.2).

The issues and site programs related to the surface characteristics program, along with their SCP section number, are as follows:

Issue or program	Short title
1.8	NRC siting criteria (Section 8.3.5.17)
1.9	Higher level findings--postclosure (Section 8.3.5.18)
1.11	Configuration of underground facilities--postclosure (Section 8.3.4.2)
4.4	Preclosure design and technical feasibility (Section 8.3.2.5)
8.3.1.4	Rock characteristics
8.3.1.12	Meteorology program

Issue or program	Short title
8.3.1.15	Thermal and mechanical properties program
8.3.1.16	Preclosure hydrology
8.3.1.17	Preclosure tectonics

8.3.1.14.1 Investigation: Studies to provide the topographic characteristics of potential locations of surface facilities

Purpose and objectives of the investigation

The purpose of this investigation was to evaluate the surface topographic elevation and relief at the potential surface facility locations to provide a basis for evaluating 1) the surface drainage, flood levels, and erosion characteristics in the vicinity of Yucca Mountain, 2) the cut-and- fill requirements for the design and engineering of the ESF and repository surface facilities, and 3) the stability of natural slopes and cut slopes. Topographic maps will be used in locating surface facilities, roads, and railways.

The surface topographic information resulting from this investigation will contribute to data needs in the following design issues and characterization programs:

Issue or program	Subject
8.3.1.16	Preclosure hydrology. Topographic contours will be used to determine flood level.
4.4	Preclosure design and technical feasibility (Section 8.3.2.5). Topographic contours will be used in the design and therefore influence the technical feasibility of the technologies required for repository construction, operation, closure, and decommissioning.
1.11	Configuration of underground facilities (postclosure) (Section 8.3.2.2). Topographic contours will be used to determine if the site has less than 200 m of overburden, which would result in disqualification (Section 8.3.5.18). Topographic contours will also be used to determine if the site is favorable with a minimum overburden depth of 300 m (Section 8.3.5.17).
8.3.1.4	Rock characteristics. Topographic contours will be used to determine in situ stress at depth considering surface topography variations.
8.3.1.15	Thermal and mechanical properties. Topographic contours will be used to determine in situ stress at depth considering surface topography variations.

8.3.1.14.2 Investigation: Studies to provide soil and rock properties of potential locations of surface facilities and subsurface access facilities

Purpose and objectives of the investigation

The characteristics of the soil and rock at or near the surface will primarily influence the selection of the surface facilities locations and their design and contribute to the siting of the ramps and shafts. The soil and rock conditions also provide information on infiltration-runoff characteristics and erosion potential so that the site drainage and erosion control systems can be designed when the facility design has been completed.

8.3.1.14.2.1 Study: Exploration program

The objectives of this study are to conduct an exploration program for characterization of the soil and rock conditions that will influence or be influenced by the construction of the surface facilities and subsurface access ramps and shafts. The exploration program study will consist of two activities: 1) site reconnaissance and 2) preliminary and detailed exploration.

8.3.1.14.2.1.1 Activity: Site reconnaissance

Objectives

The objectives of this activity are to review existing site information and conduct a field reconnaissance to establish a preliminary exploration program to include further topographic and geologic mapping, subsurface drilling, test pits, trenching, and geophysical methods. Data from this activity will contribute to the development of the geotechnical parameters required for the resolution of Design Issue 4.4 (Section 8.3.2.5).

8.3.1.14.2.1.2 Activity: Preliminary and detailed exploration

Objectives

The primary objective of the preliminary explorations is to obtain sufficient surface and subsurface data to prepare a preliminary design for the ESF surface and subsurface access facilities. Preliminary designs based on these explorations will be suitable for economic and technical feasibility reports and YMP planning reports. The depth, thickness, and areal extent of all major soil and rock strata that will influence or be influenced by the construction of the surface facilities and subsurface ramps and shafts must be established in reasonable detail. In addition, samples must be obtained for laboratory testing to provide a basic knowledge of the engineering properties of the various strata.

8.3.1.14.2.1.3 Activity: Detailed exploration

The objectives of this activity were intentionally omitted, the planned scope of work will be completed under Activity 8.3.1.14.2.1.2.

8.3.1.14.2.2 Study: Laboratory tests and material property measurements

The objective of this study is to conduct laboratory tests and material property measurements on representative samples of soil and rock. These tests and measurements are intended to determine physical, mechanical, and dynamic properties. Additional tests and measurements will be conducted on soils to determine index properties and moisture-density compaction curves for potential fill material. Geotechnical information from this study will contribute to the development of the geotechnical design parameters, which in turn will be used to address Design Issue 4.4 (Section 8.3.2.5).

8.3.1.14.2.2.1 Activity: Physical property and index laboratory tests

Objectives

The objective of this activity is to measure the soil or rock weight and volume components using physical property tests. Soils can be further characterized by index tests such as gradation analysis and Atterberg limits testing. The physical and index property test results are used to classify soils and rocks, to group soils and rocks in major strata, and to extrapolate results from a restricted number of mechanical and dynamic properties tests to determine properties of other similar materials. Empirical methods can also be used to relate the physical properties and soil or rock classifications to engineering parameters.

8.3.1.14.2.2.2 Activity: Mechanical and dynamic laboratory property tests

Objectives

The objective of this activity is to measure in the laboratory the static and dynamic deformation and strength characteristics of soil and rock samples obtained from the exploratory program. The results of this testing will be used to evaluate bearing capacity, earth pressures, shear strength parameters, slope stability, settlement and swelling potentials, and the dynamic characteristics of the soil and rock. This geotechnical information will be used for locating and designing buildings, foundations, retaining walls, backfills, roads, slopes, shafts, and ramps.

8.3.1.14.2.3 Study: Field tests and characterization measurements

The objective of this study is to conduct field tests and characterization measurements. These field tests are intended to determine the in situ physical, mechanical, and dynamic properties of the soil and rock. Characterization measurements will be conducted on the rock for the purpose of

classifying the rock and quantitatively describing the rock structure. Geophysical field measurements will help develop a three-dimensional model of the subsurface soil and rock strata in addition to determining their dynamic properties. Geotechnical information from this study will contribute to the development of the geotechnical design parameters which in turn will be used to address Design Issue 4.4 (Section 8.3.2.5).

8.3.1.14.2.3.1 Activity: Physical property field tests and characterization measurements

Objectives

The objectives of this activity are to classify and describe the soil and rock conditions in the field and to determine their physical properties. The results of these tests and measurements will be used to develop estimates of the engineering characteristics of the soil and rock. In addition, these properties and measurements will aid in the grouping of soil and rock into stratigraphic units and the extrapolation of results from a restricted number of mechanical and dynamic properties tests to zones of soil and rock with similar material properties.

8.3.1.14.2.3.2 Activity: Mechanical property field tests

Objectives

The objective of this activity is to measure the deformation and strength characteristics of in situ soil and rock conditions. The results of this testing will be used to evaluate bearing capacity, earth pressures, settlement and swelling potentials, slope stability, and the dynamic response of soil and rock for the design of foundations, retaining walls, backfills, roads, slopes, ramps, and shafts.

8.3.1.14.2.3.3 Activity: Geophysical field measurements

Objectives

Geophysical methods will be used to obtain measurements of the compressional and shear wave velocities, and to determine the velocity structure in the area of the ESF surface facilities and subsurface ramps and shafts. These methods may also be used to profile the alluvium-bedrock contact, locate discontinuities or other structural abnormalities, and determine the depth, thickness, and lateral extent of soil and rock stratigraphic units.

8.3.1.15 Objectives of the thermal and mechanical rock properties program

Summary of performance and design requirements for thermal and mechanical rock properties information

This program provides all site information needed on thermal and mechanical rock properties and on ambient stress and temperature conditions. The issues specifically requesting information from this characterization program are summarized in the following table.

Data required	Issue	Short title	SCP section
Thermal properties of host rock for analyses related to waste package design	1.10	Waste package characteristics (postclosure)	8.3.4.2
Thermal/mechanical properties of the rock for rock for repository design and in situ stress and temperature conditions for initial and boundary conditions for design calculations	1.11	Configuration of underground facilities (postclosure)	8.3.2.2
	1.12	Seal characteristics	8.3.3.2
	4.	Preclosure design and technical feasibility	8.3.2.5
Thermal properties of rock for disturbed zone analysis	1.6	Ground-water travel time	8.3.5.12
Bulk properties and radon emanation rate for radiologic safety analysis	2.7	Repository design criteria for radiological safety	8.3.2.3
	2.2	Worker radiological safety (normal conditions)	8.3.5.4

8.3.1.15.1 Investigation: Studies to provide the required information for spatial distribution of thermal and mechanical properties

Purpose and objectives of the investigation

The purpose of this investigation is to provide the information on spatial distribution of thermal and mechanical properties requested by performance and design issues. The performance allocation process identified performance measures and goals. To determine whether the performance goals can be met, data must be available on various site parameters, and the data must have associated levels of confidence.

8.3.1.15.1.1 Study: Laboratory thermal properties

The objective of this study is to provide laboratory characterization of thermal conductivity and heat capacity and the spatial variability thereof. In order to do so, porosity, grain density, and the heat capacity and thermal conductivity of zero-porosity material also must be characterized.

The validity of extrapolation of laboratory-determined thermal properties to in situ conditions will be examined by comparison of the properties with data obtained from in situ heater tests in the ESF. Temperature fields induced during the heater tests will be modeled using numerical techniques, with values for thermal properties being varied until an optimum match of predicted and actual temperatures is obtained.

8.3.1.15.1.1.1 Activity: Density and porosity characterization

Objectives

The objective of this activity is to obtain data on density and porosity and to evaluate the spatial variability thereof. Data will contribute to determination of in situ thermal properties (porosity and grain density), to vertical in situ stress (bulk density), and radiation-shielding properties (bulk density).

8.3.1.15.1.1.2 Activity: Volumetric heat capacity characterization

Objectives

The objectives of this activity are to obtain data for volumetric heat capacity and to evaluate the spatial variability thereof. The data will be used in calculations of the thermal response to the presence of heat-producing waste in unit TSw2.

8.3.1.15.1.1.3 Activity: Thermal conductivity characterization

Objectives

The objectives of this activity are to obtain data for thermal conductivity and to evaluate the spatial variability thereof. The data will be used in calculations of the thermal response to the presence of heat-producing waste in unit TSw2.

8.3.1.15.1.2 Study: Laboratory thermal expansion testing

The objective of this study is to provide laboratory characterization of thermal-expansion behavior and the spatial variability thereof. The discussion that follows applies for each new core hole and for the ESF. Testing frequency at the MTL in the ESF will depend on spatial variability.

8.3.1.15.1.2.1 Activity: Thermal expansion characterization

Objectives

The objective of this activity is to obtain data for thermal-expansion behavior and to evaluate the spatial variability thereof. The data will be used in calculations of thermal stress and deformation associated with the temperature field produced by the presence of heat-producing waste in unit TSw2.

8.3.1.15.1.3 Study: Laboratory determination of mechanical properties of intact rock

The objective of this study is to provide laboratory characterization of the mechanical properties of intact rock and the spatial variability thereof. The discussion for Activity 8.3.1.15.1.3.1 applies for each new core hole and for the ESF. Testing frequency at the MTL in the ESF will depend on spatial variability.

8.3.1.15.1.3.1 Activity: Compressive mechanical properties of intact rock at baseline experiment conditions

Objectives

The objective of this activity is to obtain data for the compressive mechanical properties of intact rock, and the spatial variability thereof, for baseline experiment conditions. These data will be used in mechanical and thermomechanical calculations of stresses and deformations induced by the presence of underground openings in unit TSw2 and overlying units and by the presence of heat-producing waste in unit TSw2.

8.3.1.15.1.3.2 Activity: Effects of variable environmental conditions on mechanical properties

Objectives

The objective of this activity is to evaluate the effects of varying sample size, strain rate, temperature, confining pressure, lithophysal content, saturation state, and anisotropy on compressive mechanical properties. In addition, the tensile strength of unit TSw2 will be measured. Data will be used in mechanical and thermomechanical calculations of stresses and deformations induced by the presence of underground openings in unit TSw2 and overlying units and by the presence of heat-producing waste in unit TSw2.

8.3.1.15.1.4 Study: Laboratory determination of the mechanical properties of fractures

The objective of this study is to provide laboratory characterization of the mechanical properties of fractures and the spatial variability thereof. The discussion applies for each new core hole and for the ESF.

8.3.1.15.1.4.1 Activity: Mechanical properties of fractures at baseline experiment conditions

Objectives

The objective of this activity is to obtain data for the mechanical properties of fractures, and the spatial variability thereof, for baseline experiment conditions. The data will be used in mechanical and thermomechanical calculations of the stresses and deformations induced by the presence of underground openings in unit TSw2 and overlying units and by the presence of heat-producing waste in unit TSw2.

8.3.1.15.1.4.2 Activity: Effects of variable environmental conditions on mechanical properties of fractures

Objectives

The objective of this activity is to evaluate the effects of varying normal stress, displacement rate, temperature, sample size, fracture roughness, and saturation state on the mechanical properties of artificial and natural fractures. The data will be used in mechanical and thermomechanical calculations of stresses and deformations induced by the presence of underground openings in unit TSw2 and overlying units and by the presence of heat-producing waste in unit TSw2.

8.3.1.15.1.5 Study: Excavation investigations

The objective of this study is to obtain site-specific information concerning the behavior of underground excavations in the proposed repository horizon and overlying units. Most of the data will be used for testing of computer codes that will be used to predict mechanical behavior of the rock mass. In addition, some of the information will serve as direct demonstration of constructability with reasonably available technology (relevant to resolution of Issue 4.4).

8.3.1.15.1.5.1 Activity: Shaft convergence

The shaft convergence test is to be deferred until after construction and other prioritized ESF testing activities have been completed. The status and scope of the test is currently being addressed for ESF ramp accesses to be consistent with the reference ESF design concept described in Section 8.4.

Objectives

The objectives of this activity are to monitor rock-mass deformation around a vertical shaft and to measure horizontal in situ stresses. In situ stress data will contribute to definition of boundary and initial conditions for mechanical and thermomechanical analyses, whereas observations of rock-mass deformation also will contribute to empirical evaluations of nonradiological health and safety (Issue 4.2 of the SCP).

8.3.1.15.1.5.2 Activity: Demonstration breakout rooms

Objectives

The major objective of this activity is to demonstrate constructability and stability of underground rooms with cross-sectional dimensions equivalent to those of a repository in both lithophysae-rich and lithophysae-poor material. This demonstration will include an evaluation of the deformations that occur around the openings. A secondary objective is to provide facilities for other testing (e.g., heater tests and overcoring). Demonstration of constructability and stability will contribute to empirical evaluations of nonradiological health and safety (Issue 4.2 of the SCP).

8.3.1.15.1.5.3 Activity: Sequential drift mining

Objectives

The objectives of this activity are to obtain data on the deformation response of drifts with cross-sectional dimensions equivalent to those of a repository in welded tuff, to use the data in code evaluation activities, and to demonstrate constructability and stability of repository-sized drifts in lithophysae-poor material. Data will contribute to validation of computer codes to be used to calculate mechanical responses, as well as contributing to empirical evaluations related to nonradiological health and safety (Issue 4.2 of the SCP).

8.3.1.15.1.6 Study: In situ thermomechanical properties

The objective of this study is to obtain data on in situ thermal and thermomechanical properties for units TSw1 and TSw2. Some of the data will be used for testing computer codes used in heat transfer and thermomechanical calculations. Additional heater experiments will be conducted to characterize the waste container environment, as discussed in Section 8.3.4.2.4.

8.3.1.15.1.6.1 Activity: Heater experiment in unit TSw1

The heater experiment in unit TSw1 has been proposed to be conducted in the primary science ramp (north ramp). The test, however, will be deferred until after construction and other prioritized ESF testing activities have been completed.

Objectives

The objectives of this activity are to estimate the in situ thermomechanical properties of lithophysae-rich tuff (unit TSw1) and to evaluate the thermal and mechanical response of this tuff unit to elevated temperatures. The data will be used to evaluate models during this and other experiments.

8.3.1.15.1.6.2 Activity: Canister-scale heater experiment

Objectives

The objective of this activity is to obtain thermal and thermomechanical rock-mass measurements of the effects of thermal inputs on a representative (canister-scale) waste-emplacement borehole in lithophysae-poor tuff (unit TSw2). The data will be used to evaluate the thermal and thermomechanical models. Early testing will simulate heat fluxes expected during repository operations to evaluate geomechanical models. The heat fluxes will be increased subsequently during a thermal overdrive to determine the upper heat limit for waste-emplacement borehole stability.

8.3.1.15.1.6.3 Activity: Yucca Mountain heated block

Objectives

The objectives of this activity are to estimate in situ mechanical and thermomechanical properties of unit TSw2 and to test thermomechanical computer models. Data on the properties will be used in mechanical and thermomechanical calculations of stresses and deformations induced by the presence of underground openings in unit TSw2 and overlying units and by the presence of heat-producing waste in unit TSw2.

8.3.1.15.1.6.4 Activity: Thermal stress measurements

Objectives

The objective of this activity is to monitor changes in thermally induced stress in jointed welded tuffs in an accelerated test. The data will be used to evaluate thermally induced stresses calculated with thermomechanical computer codes. The focus of this experiment is directed toward evaluating drift stability as it might affect retrievability.

8.3.1.15.1.6.5 Activity: Heated room experiment

Objectives

The objectives of this activity are 1) to evaluate the thermomechanical response of welded tuff around repository openings to expected repository conditions during both construction and operation, 2) to develop a data base for evaluating thermal and thermomechanical design analyses and methods applicable for repository considerations, and 3) to use actual site data in predicting drift response and support/rock interactions during construction, operation, retrievability, and postclosure.

8.3.1.15.1.7 Study: In situ mechanical properties

The objectives of this study are to obtain in situ measurements of the mechanical properties of the rock mass for unit TSw2. Mechanical properties include rock-mass deformability and evaluations of responses of single and multiple joints to controlled loadings. The numbers of experiments to obtain such properties will not fulfill requirements for confidence as expressed by performance and design issues. Therefore, the data will be used as preliminary indicators of rock-mass values and as checks of the validity of extrapolation of laboratory-determined data to in situ conditions. In addition, measurements of rock-mass deformation modulus in different locations will provide an estimate of spatial variability of rock-mass mechanical properties. Necessary information about fractures that is relevant to individual test locations (as well as to Yucca Mountain as a whole) will be gathered as part of Study 8.3.1.4.2.2.

8.3.1.15.1.7.1 Activity: Plate loading tests

Objectives

The objectives of this activity are to measure the deformation modulus of the rock mass and to evaluate the zone of increased fracturing adjacent to underground openings. Modulus data are to be used in thermomechanical calculations of the stresses and deformations induced by the presence of underground openings in unit TSw2 and overlying units and by the presence of heat- producing waste in unit TSw2. Characterization of the zone of increased fracturing will contribute to the definition of initial conditions, boundary conditions, and properties to be used in the calculations.

8.3.1.15.1.7.2 Activity: Rock-mass strength experiment

Objectives

The objective of this activity is to evaluate the mechanical behavior of the rock mass or its components. Experiments will be performed to obtain information with regards to the mechanical strength of single joints and multiply jointed volumes of rock. It is envisaged that this experiment will be conducted in several areas that are representative of the range of conditions encountered in the ESF. The information will be used to evaluate potential scale effects between laboratory and in situ conditions, to provide data to evaluate empirical design criteria, and to provide data to evaluate and validate jointed-rock models.

8.3.1.15.1.8 Study: In situ design verification

The objectives of this study are to 1) investigate the effects of the spatial variability of the rock on drift stability, mining activities, and ground supports; 2) evaluate techniques for underground excavation and ground support, for selecting ground supports to be used in different rock types, and for monitoring drift stability; 3) quantify the emanation of radon into repository drifts and observe its dispersion with airflow, and 4) measure parameters needed to design repository ventilation systems.

8.3.1.15.1.8.1 Activity: Evaluation of mining methods

Objectives

The objective of this experiment is to develop recommendations for mining in the repository by monitoring and evaluating mining activities in the ESF, and by conducting mining investigations.

8.3.1.15.1.8.2 Activity: Monitoring of ground-support systems

Objectives

The objective of this experiment is to develop recommendations for a ground-support methodology to be used in drifts in the repository, based on evaluations of the ground-support methodology used in the ESF, and on experimentation with other ground-support configurations. Recommendations will be made for support systems to be used, as well as for methods of selection of supports that are appropriate for the ground conditions encountered.

8.3.1.15.1.8.3 Activity: Monitoring drift stability

Objectives

The objectives of this experiment are to 1) provide confidence in predictions of usability of the repository underground facilities over their 100-yr operational life, 2) contribute to evaluations of the effectiveness of mining methods and ground-supports (Activities 8.3.1.15.1.8.1 and 8.3.1.15.1.8.2), 3) calibrate and refine criteria for determining stability of the openings, and 4) develop techniques for monitoring stability of the repository drifts.

8.3.1.15.1.8.4 Activity: Air quality and ventilation experiment

Objectives

The objectives of this experiment are to 1) measure the rate of radon emanation from the repository host rock and 2) evaluate parameters and variables needed as input to or for testing of the models to be used for design of the ventilation systems in the repository underground facility.

8.3.1.15.2 Investigation: Studies to provide the required information for spatial distribution of ambient stress and thermal conditions

Purpose and objectives of the investigation

The performance allocation process as implemented by performance assessment and design has identified performance measures and goals. To determine whether the performance goals can be met,

data must be available on various site parameters, and the data must have associated levels of confidence. The parameters and associated confidence levels are identified in the performance assessment and design issues and serve as the basis for planning of a site characterization program.

8.3.1.15.2.1 Study: Characterization of the site ambient stress conditions

The objective of this study is to characterize the ambient (pre-repository) state of stress of the Yucca Mountain host rock and surrounding units for use as initial conditions for geomechanical models used in the design and performance assessment of the repository underground facilities.

8.3.1.15.2.1.1 Activity: Anelastic strain recovery experiments in core holes

Objectives

The objective of these experiments using samples from core holes is to determine the horizontal stresses at Yucca Mountain and especially the spatial variability thereof. In situ stress data will contribute to definition of initial and boundary conditions for mechanical and thermomechanical analyses.

8.3.1.15.2.1.2 Activity: Overcore stress experiments in the Exploratory Studies Facility

Objectives

The primary objectives of these experiments are 1) to determine the in situ state of stress above, within, and below the repository host rock in that portion of the repository block penetrated by the ESF and 2) to evaluate the extent to which the ambient stress conditions are redistributed adjacent to excavations. In situ stress data will contribute to definition of initial and boundary conditions for mechanical and thermomechanical analyses.

8.3.1.15.2.2 Study: Characterization of the site ambient thermal conditions

The objective of this study is to characterize the ambient (pre-repository) temperature of the Yucca Mountain host rock and surrounding units for use as initial conditions for thermomechanical models used in the design and performance assessment of the repository underground facilities.

8.3.1.15.2.2.1 Activity: Surface-based evaluation of ambient thermal conditions

Objectives

The objectives of this activity are 1) to measure in existing wells the spatial variation of temperature with depth and to provide baseline temperatures within the repository host rock and surrounding units, 2) to measure thermal conductivity (near 25°C) of core samples as a check on independent thermal property determinations at various temperatures, and 3) to determine heat flow at Yucca Mountain.

8.3.1.16 Objectives of preclosure hydrology program

Summary of performance and design requirements for hydrology information

The preclosure hydrology test program addresses the requirements of performance and design issues. The hydrologic conditions, which include the potential for flooding, the availability of water for repository construction and operation, and the subsurface hydrologic conditions both within and above the repository horizon, must be examined to determine if engineering measures that require excessive cost, or technology beyond that which is reasonably available, will be needed.

The preclosure hydrology program (this section) and the geohydrology program (Section 8.3.1.2) will obtain specific data required for the design of the systems and components that are important to safety (ITS). The descriptions and analyses will consider the margins of safety under conditions that may result from expected operational occurrences, including those of natural origin such as flooding. These analyses must also consider the adequacy of structures provided for the prevention of accidents and mitigation of their consequences, including natural phenomena. Thus, information on the flash flood potential of the site is needed to aid in the design of the flood control measures, should they be required.

Four issues (Issues 1.11, 1.12, 4.2, and 4.4) request data from the preclosure hydrology program. The requests for hydrologic data can be summarized as follows:

1. Information required for Issue 4.4 (technical feasibility, Section 8.3.2.5) and Issue 4.2 (nonradiological health and safety, Section 8.3.2.4) relates to the potential for surface flooding. Flood frequency and magnitude data are needed for analyses being performed to determine the impacts of potential flooding on the design of the surface facilities.

2. The second type of data requested by Issue 4.4 are the parameters required to locate adequate and alternative sources of water for the repository. Current plans are to develop two new wells for repository water supply. In the event of well failures, an alternative source of water also must be available. Existing wells J-12 and J-13 could be adequate for repository-related water needs and will be considered in the evaluation for suitable alternative sources. Characteristics of aquifers proximal to the site will be evaluated to identify potentially suitable sources. Modeling studies in support of Activity 8.3.1.2.3.3.3 will determine the possible changes to the flow system that might result from withdrawals made from the wells supplying water for the repository and from the proposed alternative sources.

3. Issues 4.4 (technical feasibility, Section 8.3.2.5), 1.11 (configuration of underground facilities, Section 8.3.2.2), and 1.12 (seal characteristics, Section 8.3.3.2) require a description of the hydrologic conditions within and above the repository horizon. This information is needed to estimate moisture content, flux, and potential moisture influx above and within the host horizon, as well as the potential for perched water zones, which will be used as input for the design of the repository, shaft liners, and seals.

8.3.1.16.1 Investigation: Flood recurrence intervals and levels at potential locations of surface facilities

Purpose and objectives of the investigation

To meet the purpose of identifying the potential hazards associated with floods and debris movement, three objectives must be met: 1) to determine the magnitudes and frequencies of major flood events that can potentially occur during the period of repository operation, 2) to identify all potential areas of inundation, and 3) to determine the quantities and size characteristics of debris transported by flooding.

8.3.1.16.1.1 Study: Characterization of flood potential of the Yucca Mountain site

This study contains one activity and evaluates the potential for flooding in the many small, dry, desert washes that drain Yucca Mountain. This evaluation will be used for designing the surface facilities for the proposed repository. Proper design for flood potential is necessary to ensure the safety of the workers and the surface facilities.

8.3.1.16.1.1.1 Activity: Site flood and debris hazards studies

Objectives

The objective of this activity is to assess the flood and debris hazards at and near the potential repository surface facilities locations to allow adequate design of facilities to prevent or reduce hazards to an acceptable level.

8.3.1.16.2 Investigation: Location of adequate water supplies

Purpose and objectives of the investigation

To meet the purpose of identifying the most suitable water supply and alternative, the following objectives must be met: 1) determine the adequacy of existing wells J-12 and J-13 in terms of available resource potential, total cost, and technologic feasibility as an alternative water supply for a repository at Yucca Mountain (water rights are discussed in Section 8.3.1.11), 2) identify and locate a primary source of water for a repository at Yucca Mountain, 3) identify and locate potential alternative

sources of water, and 4) determine the potential effects of repository-related water withdrawals on the local flow system at Yucca Mountain.

8.3.1.16.2.1 Study: Location of adequate water supply for construction, operation, closure, and decommissioning of a mined geologic disposal system at Yucca Mountain, Nevada

8.3.1.16.2.1.1 Activity: Assessment of the cost, feasibility, and adequacy of wells J-12 and J-13 for use as the alternative water supply for a mined geologic disposal system at Yucca Mountain, Nevada

Objectives

The objective of this activity is to determine 1) the adequacy of wells J-12 and J-13 in terms of available resource potential and 2) the total cost and technical feasibility of supplying the water needed to support a repository at Yucca Mountain. These wells will be evaluated for use as alternative sources.

8.3.1.16.2.1.2 Activity: Location of a primary water supply for a mined geologic disposal system at Yucca Mountain, Nevada

Objectives

The objective of this activity is to identify and locate a primary source of water for a repository at Yucca Mountain. Ideally, the primary sources would be located nearer to the surface facilities than wells J-12 and J-13, and at an elevation above the surface facilities, thereby reducing distribution costs and total pumping lifts.

8.3.1.16.2.1.3 Activity: Location of alternative water supplies for a mined geologic disposal system at Yucca Mountain, Nevada.

Objectives

The objective of this activity is to identify and locate an alternative source of water for a repository at Yucca Mountain in the event that the primary source cannot meet the water demand.

8.3.1.16.2.1.4 Activity: Identification and evaluation of potential effects of repository related withdrawals on the local flow system at Yucca Mountain, Nevada

Objectives

The objective of this activity is to determine the potential effects of repository-related water withdrawals on the local flow system at Yucca Mountain. The potential effects from water withdrawal

include modifications to the preclosure ground-water travel path and the lowering of the potentiometric surface. Such effects will be identified and quantified to establish any mitigating measures that might be required.

8.3.1.16.3 Investigation: Ground-water conditions within and above the potential host rock

Purpose and objectives of the investigation

To meet the purpose of describing the baseline characteristics of the unsaturated zone within and above the repository horizon, the following objectives must be met: 1) determine the amount of water inflow to the repository horizon including seasonal variations in inflow rate, 2) determine the existence of perched water, and 3) define the locations, depths, thickness, lateral extent, seasonal variation, and degree of saturation of perched water zones if any are identified. These data will be obtained from the geohydrology program (8.3.1.2); the preclosure hydrology program will synthesize the data to help resolve the design issues.

8.3.1.16.3.1 Study: Determination of the preclosure hydrologic conditions of the unsaturated zone at Yucca Mountain, Nevada

8.3.1.16.3.1.1 Activity: Synthesis of data from site program 8.3.1.2 to determine the preclosure hydrologic characteristics of the unsaturated zone at Yucca Mountain, Nevada

Objectives

The objectives of this activity are to compile the data collected under geohydrology Investigation 8.3.1.2.2, in Study 8.3.1.2.2.4 (ESF investigations) for input to design Issue 4.4 (Section 8.3.2.5).

8.3.1.17 Objectives of the preclosure Tectonics Program

Summary of performance and design requirements for preclosure tectonics information

The preclosure tectonics program (Program 8.3.1.17) is designed to develop an understanding of and to characterize the tectonic events and processes that could impact proposed repository structures, systems, or components considered to be ITS through the operational phase; i.e., until permanent closure is achieved. In addition, characterizations of tectonic processes and events will be developed for consideration in the design and operation of certain structures, systems, and components required for exercising the retrieval option. Tectonic processes and events that are relevant to waste isolation following permanent closure will be investigated within the postclosure tectonics program (Program 8.3.1.8).

Data requirements come from Issue 4.4 (Section 8.3.2.5), which evaluates the technical feasibility of repository construction, operation, closure, and decommissioning, and from postclosure Issue 1.12 (Section 8.3.3.2), which considers the design of seals for shafts, drifts, and boreholes. Investigations of technical feasibility include data requirements from three additional performance and

design issues. These three issues are preclosure radiological safety (Issue 2.7, Section 8.3.2.3), potential radiologic exposure to the public due to credible accidents (Issue 2.3, Section 8.3.5.5), and preservation of the waste retrieval option (Issue 2.4, Section 8.3.5.2). In addition, data developed by the preclosure tectonics program will be used by the postclosure tectonics program (Program 8.3.1.8) and the preclosure and postclosure rock characteristics programs (Programs 8.3.1.15 and 8.3.1.4).

The evaluation of technical feasibility (Issue 4.4, Section 8.3.2.5) establishes the major requirement for characterizing potentially disruptive tectonic events.

8.3.1.17.1 Investigation: Studies to provide required information on volcanic activity that could affect repository design or performance

Purpose and objectives of the investigation

Two types of volcanic hazards that could credibly affect preclosure repository performance will be characterized: 1) ash fall from distal silicic volcanic centers in the western Great Basin and 2) a basaltic volcanic eruption at the site. Ash fall is being addressed under preclosure tectonics because of its potential impact on surface and subsurface ventilation systems (dust filters). However, the study of basaltic volcanism in the site region will be conducted under the postclosure tectonics program (Section 8.3.1.8), because the probability of basaltic volcanism at the site is greater over the longer postclosure time frame. The probability of a basaltic volcanic eruption at the site during the preclosure period will be estimated there. No studies are planned of potential silicic volcanism in the site region because a silicic volcanic eruption at the site is not considered a credible event (Section 1.5.1).

The characterization parameters related to ash fall are being provided so that the filtration systems of the surface-facility and mining ventilation systems can be designed to accommodate potential ash falls at the site. The characterization parameters related to basaltic volcanism are intended to provide assurance that the probability of a volcanic eruption at the site is acceptably low (i.e., as interpreted here, less than one chance in 10,000 in 100 yr).

8.3.1.17.1.1 Study: Potential for ash fall at the site

8.3.1.17.1.1.1 Activity: Survey literature regarding Quaternary silicic volcanic centers in the western Great Basin

Objectives

The objective of this activity is to compile information on Quaternary silicic volcanism in the western Great Basin, the reoccurrence of which might produce an ash fall at the site.

8.3.1.17.1.1.2 Activity: Assess potential ash-fall thickness at the site

Objectives

The objective of this activity is to produce an approximate probability- versus-thickness function for potential ash falls at the site and to estimate a particular ash-fall thickness that has less than one chance in ten of occurring in 100 yr. These hazard estimates will be considered in the design of filters in the mining and surface-facility ventilation systems.

8.3.1.17.1.1.3 Activity: Assess potential particle density and size distribution of ash fall at the site

Objectives

The objective of this activity is to estimate the potential particle densities and particle-size distributions of ash falls at the site for consideration in the design of filters in the mining- and surface-facility ventilation systems.

8.3.1.17.2 Investigation: Studies to provide required information on fault displacement that could affect repository design or performance

Purpose and objectives of investigation

The siting objective vis-a-vis potential surface faulting is to avoid fault displacement in excess of a few inches beneath the structural foundations of surface facilities considered ITS. The corresponding goal of this investigation is to demonstrate, with a high degree of confidence, that there is less than a one percent chance of exceeding 5 cm of fault displacement beneath surface facilities important to safety (FITS) during the preclosure period (approximately 100 yr).

The primary concern regarding faulting in the underground facilities during preclosure is that waste packages might be sheared or become jammed in their waste-emplacement boreholes, making retrieval more difficult and time consuming than it otherwise would be. The corresponding goal is to demonstrate with a moderate degree of confidence that there is less than a ten percent chance of exceeding 7 cm of fault displacement in areas of emplaced waste in 100 yr, considering all faults that may intersect these areas. (A displacement of 7 cm is the minimum value at which the sides of a faulted waste-emplacement borehole would be expected to contact a waste package.)

8.3.1.17.2.1 Study: Faulting potential at the repository

8.3.1.17.2.1.1 Activity: Assess the potential for surface faulting at prospective sites of surface facilities important to safety

Objectives

The objective of this activity is to assess the stability of the site surface with respect to fault displacement, at locations proposed for FITS.

8.3.1.17.2.1.2 Activity: Assess the potential for displacement on faults that intersect underground facilities

Objectives

The objective of this activity is to assess the potential for displacement on faults that intersect underground facilities.

8.3.1.17.3 Investigation: Studies to provide required information on vibratory ground motion that could affect repository design or performance

Purpose and objectives of the investigation

The purposes of this investigation are to 1) develop a seismic-design basis for repository facilities that are ITS and 2) provide other information that will facilitate the assessment of the adequacy of the seismic-design basis and the identification of credible accidents that might be initiated by seismic events and lead to release of radioactive materials. The seismic-design basis will account for both the potential occurrence of earthquakes on nearby faults and potential future underground nuclear explosions (UNEs) at the NTS.

8.3.1.17.3.1 Study: Relevant earthquake sources

The objectives of this study are to identify and characterize those earthquake sources that are relevant to a deterministic seismic hazard analysis of the site (i.e., those sources that could be active) and, if active, could cause severe ground shaking at the site. Potential earthquake sources include faults with surface geologic expression as well as concealed faults. Each seismic source will be characterized by its location, depth, orientation, likely style of faulting, and 10,000-yr cumulative slip earthquake magnitude.

8.3.1.17.3.1.1 Activity: Identify relevant earthquake sources

Objectives

The objective of this activity is to identify earthquake sources that could generate severe ground motions at the site.

8.3.1.17.3.1.2 Activity: Characterize 10,000-yr cumulative slip earthquakes for relevant seismogenic sources

Objectives

The objective of this activity is to characterize 10,000-yr cumulative slip earthquakes for each of the relevant seismogenic sources identified in the previous activity. The nature, size, and location of 10,000-yr cumulative slip earthquakes are to be established based on the seismogenic properties of the potential sources.

8.3.1.17.3.2 Study: Underground nuclear explosion sources

The objective of this study is to characterize the potential future UNEs at the NTS that region would result in the most severe motions at the repository site.

8.3.1.17.3.2.1 Activity: Determine the range of underground nuclear explosion sources

Objectives

The objective of this activity is to determine potential locations and upper limits on the yield of future UNE tests within the NTS.

8.3.1.17.3.2.2 Activity: Determine maximum underground nuclear explosion source(s)

Objectives

The objective of this activity is to identify the potential future UNE(s) that would generate the most severe ground motions at the site.

8.3.1.17.3.3 Study: Ground motion from regional earthquakes and underground nuclear explosions

Objectives

The objective of this study is to select or develop ground-motion models that are appropriate for estimating ground motion at the site from earthquakes and UNEs. These models will be used to determine the relevancy of seismic sources to a deterministic seismic hazard analysis (Activity 8.3.1.17.3.1.1), identify controlling seismic events (Activity 8.3.1.17.3.5.1), constrain simulated ground motions from controlling seismic events (Activity 8.3.1.17.3.5.2) and estimate the probabilities of exceeding given ground-motion levels at the site (Activity 8.3.1.17.3.6.2).

8.3.1.17.3.3.1 Activity: Select or develop empirical models for earthquake ground motions

Objectives

The objective of this activity is to select or develop empirical ground-motion models that are appropriate for estimating earthquake ground motion at the site. The models will predict ground motion as a function of earthquake magnitude and distance between the earthquake source and the site.

8.3.1.17.3.3.2 Activity: Select or develop empirical models for ground motion from underground nuclear explosions

Objectives

The objective of this activity is to select or develop empirical ground-motion models that are appropriate for estimating ground-motion at the site from UNEs at the NTS. The models will predict ground motion as a function of the yield and distance of the UNE.

8.3.1.17.3.4 Study: Effects of local site geology on surface and subsurface motions

Objectives

The objective of this study is to document systematic effects on surface and subsurface ground motions resulting from the local site geology. Local correction factors will be developed for application to predictions of the regional ground-motion models developed in Study 8.3.1.17.3.3. These correction factors will be based, to the extent possible, on instrumental recordings of ground motion obtained in Study 8.3.1.17.4.1. Theoretical models for the observed site effects will be developed to the extent necessary to explain the observations to first order and then used to extrapolate the observations to locations and depths where ground motions must be predicted but where recordings are not available.

8.3.1.17.3.4.1 Activity: Determine site effects from ground-motion recordings

Objectives

The objectives of this study are to determine, from ground-motion recordings, systematic effects of the local site geology on surface and subsurface motions, and to identify any significant site-wide bias in groundmotion levels, as compared with average levels for the southern Great Basin. These empirical determinations will be used to calibrate theoretical site- effects models in Activity 8.3.1.17.3.4.2.

8.3.1.17.3.4.2 Activity: Model site effects using the wave properties of the local geology

Objectives

The objective of this activity is to develop a calibrated theoretical site-effects model for use in extrapolating the observations documented in Activity 8.3.1.17.3.4.1 to locations and depths where ground-motion predictions are needed, but where instrumental recordings are not available.

8.3.1.17.3.5 Study: Ground motion at the site from controlling seismic events

The objectives of this study are to identify the controlling seismic events and to characterize the resulting controlling ground motions. Controlling seismic events are those UNEs or 10,000-yr cumulative slip earthquakes that would generate the most severe ground motions at the site, at frequencies of engineering significance.

Two activities are included in this study.

8.3.1.17.3.5.1 Activity: Identify controlling seismic events

Objectives

The objective of this activity is to identify those UNEs or 10,000-yr cumulative slip earthquakes that would produce the most severe ground motions at the site at frequencies of engineering significance. There may be more than one controlling seismic event because different events may generate the most severe ground motions in different frequency bands.

8.3.1.17.3.5.2 Activity: Characterize ground motion from the controlling seismic events

Objectives

The objective of this activity is to generate suites of strong-motion time histories and corresponding response spectra that are representative in amplitude, frequency content, and duration of site ground motions that could be generated by the controlling seismic events.

8.3.1.17.3.6 Study: Probabilistic seismic hazards analyses

The primary objective of this study is to quantify the probability for experiencing ground motions of varying degrees of severity that might result from earthquakes of varying magnitude and distance from the site. Results from this study will be used to evaluate and constrain required technical judgments in the deterministic evaluation of design-basis ground motions (such as the determination of exceptional earthquake magnitudes), evaluate the adequacy of the deterministic results, and help identify and focus efforts to refine those parameters that are most important for the deterministic calculations. The probabilistic hazard estimates will also provide information needed to assess the credibility of postulated accidents at the repository that might lead to releases of radioactive materials (Information Need 2.3.1, Section 8.3.5.5.1).

8.3.1.17.3.6.1 Activity: Evaluate earthquake sources

Objectives

The objective of this activity is to determine average rates for earthquake recurrence as a function of magnitude for the southern Great Basin to a distance of about 100km from the site, and then to apportion these rates onto active faults and subregional seismic source zones.

8.3.1.17.3.6.2 Activity: Evaluate ground motion probabilities

Objectives

The objectives of this activity are 1) to estimate the probability of exceeding given ground-motion levels at the site and 2) to integrate the contributions to that probability from all identified earthquake sources that could generate potentially damaging ground motion at the site.

8.3.1.17.4 Investigation: Preclosure tectonics data collection and analysis

Purpose and objectives of the investigation

The primary purpose of this investigation is to provide data and analyses that are required by Investigation 8.3.1.17.2, assessment of fault displacement that could affect repository design or

performance, and Investigation 8.3.1.17.3, assessment of vibratory ground motion that could affect repository design or performance. The limited data collection and analysis that is required by Investigation 8.3.1.17.1, volcanic activity that could impact the repository, will be performed within that investigation.

8.3.1.17.4.1 Study: Historical and current seismicity

The objective of this study is to compile information on reported and instrumentally recorded earthquakes that characterize the earthquake potential near Yucca Mountain. This information will be used 1) to help identify and characterize potentially relevant earthquake sources for the deterministic hazard analysis (Study 8.3.1.17.3.1) and potentially contributing earthquake sources for the probabilistic hazard analysis (Study 8.3.1.17.3.6), 2) to develop regional earthquake ground-motion models (Activity 8.3.1.17.3.3.1), and 3) to determine local-geologic and depth-of-burial effects on ground motion at the site (Activity 8.3.1.17.3.4.1).

8.3.1.17.4.1.1 Activity: Compile historical earthquake record

Objectives

The objective of this activity is to compile a record of historical seismic events in the southern Great Basin or within 100 km of Yucca Mountain. The record will be as complete and accurate as is reasonably achievable, and will indicate whether each cataloged seismic event is thought to be a natural earthquake, induced earthquake, UNEs, cavity collapse, or blast. For potentially damaging earthquakes ($M \geq 5.5$) in the study region, available information will be compiled on ground-motion intensity, availability of strong-motion records, and extent and style of faulting.

8.3.1.17.4.1.2 Activity: Monitor current seismicity

Objectives

The objective of this activity is to provide empirical information on how often earthquakes are currently occurring in the southern Great Basin; what the orientation, depth, and style of faulting are; how seismic wave amplitudes scale with magnitude and attenuate with distance in the region; and how ground motions vary with depth and with surface geology in the site area. The information on faulting and earthquake location and recurrence will be used to identify potentially relevant earthquake sources for the deterministic hazard analysis (Study 8.3.1.17.3.1) and potentially contributing earthquake sources for the probabilistic hazard analysis (Study 8.3.1.17.3.6). The information on magnitude and distance scaling will be used to develop regional ground-motion models (Study 8.3.1.17.3.3). The data on ground-motion variations at the site will be used to develop site correction factors and response functions (Study 8.3.1.17.3.4). Recordings obtained at Yucca Mountain of small earthquakes may be used as Green's functions in the simulation of controlling earthquake motions (Activity 8.3.1.17.3.5.2).

8.3.1.17.4.1.3 Activity: Evaluate potential for induced seismicity at the site

Objectives

The objective of this activity is to evaluate the potential for human activities to significantly perturb the natural seismic hazard at the site by inducing seismicity at or near the site. To date, the human activities that have been identified as having a potential to induce seismicity in the site region are the impoundment of Lake Mead, the testing of nuclear devices at NTS, and the mining of the repository itself. The information developed in this activity will be used in estimating of magnitude-recurrence relationships for earthquake sources that are relevant to the deterministic hazard analysis (Activity 8.3.1.17.3.1.1) and for earthquake sources that contribute to the probabilistic seismic hazard at the site (Activity 8.3.1.17.3.6.1).

8.3.1.17.4.2 Study: Location and recency of faulting near prospective surface facilities

Two activities are included in this study.

8.3.1.17.4.2.1 Activity: Identify appropriate trench locations in Midway Valley

Objectives

The objective of this activity is to identify appropriate trench locations at proposed locations for repository surface facilities that are ITS through detailed geologic mapping and remote sensing studies. The recommended locations will be used in trenching investigations in Activity 8.3.1.17.4.2.2.

8.3.1.17.4.2.2 Activity: Conduct exploratory trenching in Midway Valley

Objectives

The objective of this activity is to investigate the possible occurrence of late Quaternary surface fault rupture in the vicinity of planned surface facility locations ITS and to identify sites without evidence of significant late Quaternary faulting. This activity will provide input into the location and design of surface FITS, particularly those associated with waste handling.

8.3.1.17.4.3 Study: Quaternary faulting within 100 km of Yucca Mountain, including the Walker Lane

The objectives of this study are 1) to identify Quaternary faults within 100 km of Yucca Mountain and 2) to characterize those faults capable of future earthquakes with magnitude such that associated ground shaking could impact design or affect performance of the waste facility. This study is complemented by more specialized studies of faults at and proximal to the site. These studies are 8.3.1.17.4.2 (faulting potential near prospective surface facilities); 8.3.1.17.4.6 (Quaternary faulting

within the site area); 8.3.1.17.4.4 (Quaternary faulting proximal to the site within northeast-trending fault zones); 8.3.1.17.4.5 (detachment faults at or proximal to Yucca Mountain).

8.3.1.17.4.3.1 Activity: Conduct and evaluate deep geophysical surveys in an east-west transect crossing the Furnace Creek fault zone, Yucca Mountain, and the Walker Lane

Objectives

The objectives of this activity are

1. To help identify and locate potentially significant seismic source zones, including possible through-going extensions of the Walker Lane, beneath the Oligocene-Miocene cover of the Yucca Mountain area; to determine the width and subsurface geometry of such extensions and of the Furnace Creek fault zone and the relation of these features to detachment faults and to Quaternary faults; and to evaluate the postulated incipient rift zone at Crater Flat.

2. To characterize the crustal velocity structure and define lateral inhomogeneities in that structure in the Yucca Mountain area.

3. To trace the 5- and 10-s events found on Death Valley Consortium for Continental Reflection Profiling profiles through the Yucca Mountain region and, if possible, to trace reflections from the upper and lower carbonate aquifers, the Precambrian-Cambrian Pahrump Group and Noonday Dolomite, and the Proterozoic basement across the Furnace Creek fault and through the area of the projected northwest continuation in the subsurface of the Las Vegas Valley shear zone.

4. To identify differences in mass caused by variation in source lithology in the upper few kilometers of the crust, and correlate those sources with reflections obtained in the seismic reflection survey, or with conductivity features obtained in the magneto-telluric survey.

5. To identify differences in magnetic field caused by sources in the upper few kilometers of the crust and correlate those sources with reflections obtained in the seismic reflection survey, or with conductivity features obtained in the magnetotelluric survey.

6. To characterize the conductivity structure of the crust in the Yucca Mountain region, focusing in particular on the conductivity signature of the Walker Lane and Walker Belt, and if possible, tracing the signature into the subsurface of conductive units such as the Eleana Formation or nonconductive units such as the lineated and mylonitized gneisses (lower plate?) of the northern Amargosa Desert, and to correlate these features or their offsets with Quaternary faults.

7. To provide data for analysis to determine if buried magma bodies are present in the vicinity of Yucca Mountain. These data and analyses will be used to address the objective of Activity 8.3.1.8.1.1.3, (presence of magma bodies in the vicinity of the site).

8.3.1.17.4.3.2 Activity: Evaluate Quaternary faults within 100 km of Yucca Mountain

Objectives

The objectives of this activity are

1. To establish the abundance, distribution, and geographic orientation of known and suspected Quaternary faults within 100 km of the site.

2. To characterize the Quaternary and Holocene fault and fracture pattern within 100 km of the site and, if feasible, to relate that pattern to regionally important wrench fault systems, including the Walker Lane, the Death Valley-Furnace Creek fault zone, and the Mine Mountain-Pahranagat shear zone.

3. To characterize those Quaternary faults within 100 km of the site whose apparent length or recurrence rate indicate potential for future earthquakes of magnitude sufficient to affect design or performance of the waste facility.

4. To evaluate the recurrence history of that part of the Death Valley-Furnace Creek fault zone within 100 km of the site.

5. To identify fault scarps within 100 km of the site that may have been overlooked during conventional geologic field surveys and that may not have been apparent on conventional vertical aerial photography.

6. To verify the existence and age of scarps in the NTS area that were detected by low-sun-angle photogeologic interpretation.

7. To determine whether the Beatty scarp originated through tectonic or fluvial processes, or both; the nature of movement along the scarp, if tectonic; and the age of the scarp.

8. To ascertain the amount of post-middle Miocene horizontal rotation of bedrock alongside wrench faults and of bedrock suspected to be part of upper plate above subsurface wrench faults.

8.3.1.17.4.3.3 Activity: Evaluate the Cedar Mountain earthquake of 1932 and its bearing on wrench tectonics of the Walker Lane within 100 km of the site

Objectives

The objective of this activity is to evaluate the relevance of the Cedar Mountain earthquake of 1932 to potential sources of ground shaking and rupture in that part of the Walker Lane within 100 km of Yucca Mountain.

8.3.1.17.4.3.4 Activity: Evaluate the Bare Mountain fault zone

Objectives

The objectives of this activity are to

1. Evaluate the potential for ground shaking associated with future movement along the Bare Mountain fault zone.

2. Estimate the age of the most recent faulting on the Bare Mountain frontal fault.

3. Estimate the recurrence intervals of faulting.

4. Determine the nature and age of faulting within the fault complex east of the frontal zone, and to determine nature of tectonic control of the location and orientation of the main wash in Crater Flat.

5. Determine the subsurface configuration of fault zones.

8.3.1.17.4.3.5 Activity: Evaluate structural domains and characterize the Yucca Mountain region with respect to regional patterns of faults and fractures

Objectives

The objectives of this activity are to

1. Map faults and lineaments within a 100 km radius of the site and to identify those with geomorphic expression indicative of Quaternary faulting.

2. Classify the area into subareas (domains) containing relatively homogeneous fault and lineament populations (prominent geomorphic expression, density, and orientation) suggestive of Quaternary faulting. This information will be used in Activity 8.3.1.17.2.1.2 to help assess the faulting potential in areas of emplaced waste.

3. Map the areal extent of desert varnish coatings. This information will be used in Activity 8.3.1.17.4.9.1 to help establish the areal extent of tectonically stable areas near Yucca Mountain.

4. Identify areas of suspected hydrothermal alteration. This information will be used in Study 8.3.1.9.2.1 (natural resource assessment) to evaluate the relationship of the suspected hydrothermal alteration to potential mineralization in Activity 8.3.1.5.2.1.5 (calcite- and opaline-vein deposits) to aid in evaluating the possible origin of calcite-silica deposits and in Study 8.3.1.8.5.2 to aid in evaluating local heat flow anomalies.

8.3.1.17.4.4 Study: Quaternary faulting proximal to the site within northeast-trending fault zones

Objectives

The primary objective of this study is to evaluate the potential for ground motion resulting from future movement on Quaternary strike-slip faults east and south of the site-area.

8.3.1.17.4.4.1 Activity: Evaluate the Rock Valley fault system

Objectives

The objective of this activity is to determine the location, spatial orientation, length, width, Quaternary recurrence rate, and the location, amount, and nature of Quaternary movement of the Rock Valley fault system. An objective of the trenching is to estimate the total displacement, including strike-slip and dip-slip components, of Quaternary datums. Accordingly, trenching will use methods designed to facilitate measurement of these components.

8.3.1.17.4.4.2 Activity: Evaluate the Mine Mountain fault system

Objectives

The objective of this activity is to determine the location, spatial orientation, length, width, Quaternary recurrence rate, and the location, amount, and nature of Quaternary movement of the Mine Mountain fault system.

8.3.1.17.4.4.3 Activity: Evaluate the Stagecoach Road fault zone

Objectives

The objectives of this activity are to

1. Determine the location, spatial orientation, length, width, Quaternary recurrence rate, and the location, amount, and nature of Quaternary movement of the Stagecoach Road fault system.

2. Evaluate the possibility that the Stagecoach Road fault zone is a continuation of the Paintbrush Canyon fault.

3. Evaluate the geometry of the intersection in the subsurface of the Paintbrush Canyon fault and hypothesized shallow detachment faults.

8.3.1.17.4.4.4 Activity: Evaluate the Cane Spring fault system

Objectives

The objective of this activity is to determine the location, spatial orientation, length, width, Quaternary recurrence rate, and the location, amount, and nature of Quaternary movement of the Cane Spring fault system.

8.3.1.17.4.5 Study: Detachment faults at or proximal to Yucca Mountain

Objectives

The objective of this study is to supply information pertaining to the distribution, displacement rate, and age of detachment faults proximal to Yucca Mountain. The key questions regarding detachment faults are 1) whether they represent a significant earthquake source and 2) whether they conceal a significant earthquake source at depth. To resolve both questions, activities are focused on resolving the Quaternary behavior of postulated detachment faults.

This information is to be synthesized in Study 8.3.1.17.4.12 (tectonic models and synthesis), which will 1) evaluate the possibility that one or more detachment faults are present in the subsurface below or in the vicinity of the proposed repository site, and 2) if considered to be present, evaluate the direction and rate of movement of the upper plate, the depth and configuration of the fault surfaces, and the nature of the association, if any, between the detachment fault(s) and the normal faults in the upper plate.

8.3.1.17.4.5.1 Activity: Evaluate the significance of the Miocene-Paleozoic contact in the Calico Hills area to detachment faulting within the site area

Objectives

The objectives of this activity are 1) to determine whether the contact of Miocene volcanic rocks on Paleozoic strata is tectonic or depositional, 2) if tectonic, to determine the Quaternary activity, if any, of the possible detachment fault, and 3) if Quaternary, the direction and age of movement, attitude of fault plane, and nature of deformation of the Miocene (upper plate?) sequence.

8.3.1.17.4.5.2 Activity: Evaluate postulated detachment faults in the Beatty-Bare Mountain area

Objectives

The objectives of this activity are

1. To determine if postulated detachment faults in the Beatty-Bare Mountain have been active in the Quaternary, and

2. If postulated detachment faults in the Beatty-Bare Mountain have been active in the Quaternary, to

   a. Establish the displacement rate, location, and nature of the low-angle imbricate fault zones between lineated and mylonitized and variably recrystallized gneiss of the northern Amargosa Desert and the Paleozoic and Miocene rocks of the Beatty area, and to ascertain the nature of deformation of the Miocene rocks.

   b. Establish the displacement rate, location, and nature of the low-angle fault zone between Paleozoic rocks of Bare Mountain and the Miocene volcanic rocks north of Bare Mountain, and to ascertain the nature of deformation of the Miocene rocks.

   c. Ascertain the nature of internal deformation of Paleozoic rocks, their degree of metamorphism, the nature of suspected low-angle tectonic contact with the lineated and mylonitized gneiss of the northern Amargosa Desert, and the nature of the suspected low-angle tectonic contact with Miocene rocks at the northern end of Bare Mountain.

8.3.1.17.4.5.3 Activity: Evaluate the potential relationship of breccia within and south of Crater Flat to detachment faulting

Objectives

The objective of this activity is to determine whether breccias tectonically emplaced on low-angle surfaces beveled across Paleozoic and younger strata are slide masses or near-surface parts of a detached upper plate; and if either, how they relate to postulated Quaternary detachment faulting.

8.3.1.17.4.5.4 Activity: Evaluate postulated detachment faults in the Specter Range and Camp Desert Rock areas

Objectives

The objective of this activity is to determine whether the basal contact of the Horse Spring Formation is depositional or tectonic; and if tectonic, to determine whether movement was Quaternary or older and, if Quaternary, to determine the direction and amount of offset, the amount of extension, and the style of internal deformation of the upper plate.

8.3.1.17.4.5.5 Activity: Evaluate the age of detachment faults using radiometric ages

Objectives

The objectives of this activity are to

1. Determine if the subdetachment basement and the Bare Mountain massif cooled through the blocking temperatures of zircon and apatite during the Quaternary period.

2. Determine if the Northern Amargosa core complex cooled through the blocking temperatures of muscovite and biotite during the Quaternary period.

8.3.1.17.4.6 Study: Quaternary faulting within the site area

Objectives

The objectives of this study are 1) to identify and characterize Quaternary faults that intersect or project toward the surface facility, the repository, or the controlled area and 2) to identify and characterize Quaternary faults at the site whose length or recurrence rate suggest a potential for future earthquakes with magnitude such that associated ground shaking could impact design or affect performance of the waste facility.

Information from this study will be useful in estimating the probability of future rupture or ground shaking. Knowledge of the age, recurrence interval, and length of faults are required for this estimate; this information will be provided through parallel investigations described previously, and other studies of faulting.

8.3.1.17.4.6.1 Activity: Evaluate Quaternary geology and potential Quaternary faults at Yucca Mountain

Objectives

The objectives of this activity are to

1. Synthesize and evaluate data pertaining to the location, spatial orientation, length, width, Quaternary recurrence rate, and the location, amount, and nature of Quaternary movement of faults within the site area.

2. Identify hitherto unrecognized Quaternary faults within the site area.

8.3.1.17.4.6.2 Activity: Evaluate age and recurrence of movement on suspected and known Quaternary faults

Objectives

The objectives of this activity are to

1. Determine, through trenching and mapping, the location, spatial orientation, length, width, Quaternary recurrence rate, interconnections at the surface, and the location, amount, and nature of Quaternary movement of the Paintbrush Canyon, Solitario Canyon, Windy Wash, and Ghost Dance faults, and other suspected or possible Quaternary faults within the site area.

2. Determine through trenching and dating, the age, amount and nature of offset, and the recurrence history of the Bow Ridge fault system and to evaluate that information in context with data contributed by other studies on the age, nature, and origin of fracture coatings and fissure fillings deposited within that zone.

8.3.1.17.4.7 Study: Subsurface geometry and concealed extensions of Quaternary faults at Yucca Mountain

The objectives of this study are to 1) provide data on distribution of mass, magnetic gradients, geoelectric features, and seismic velocities and reflections that will aid in evaluating the continuity of Quaternary faults where concealed by Holocene and late Pleistocene surficial deposits; 2) evaluate that data and its limitations; and 3) evaluate the possibility that Quaternary faults exposed as high-angle faults at the site continue to depth as planar, high-angle faults, or alternatively, flatten at depth and merge with one or more low-angle faults. A fourth objective is to provide information on continuity of rock units within the repository and controlled area to assist the investigation of site geology (Section 8.3.1.4).

8.3.1.17.4.7.1 Activity: Evaluate intermediate depth (2 to 3 km) reflection and refraction methods and plan potential application of these methods within the site area

Objectives

The objectives of this activity are to 1) evaluate previous attempts to use seismic refraction and reflection methods at the site, 2) evaluate technology currently available, 3) evaluate potential contribution to information on velocity structure and on subsurface geometry of faults, 4) review potential applications of these methods to YMP needs, and 5) if appropriate, plan applications of these methods at the site.

8.3.1.17.4.7.2 Activity: Detailed gravity survey of the site area

Objectives

The objectives of this activity are to measure variations in mass of near-surface strata and surficial deposits, and to infer from this information the location of faults and continuity of rock units within the site.

8.3.1.17.4.7.3 Activity: Detailed aeromagnetic survey of the site area

Objectives

The objectives of this activity are to measure variations in rock magnetism of surface strata and surficial deposits and to infer from this information the location of faults and continuity of rock units within the site.

8.3.1.17.4.7.4 Activity: Detailed ground magnetic survey of specific features within the site area

Objectives

The objectives of this activity are 1) to measure variations in rock magnetism of surface strata and surficial deposits in the vicinity of specific faults, the shaft and surface facilities, drillholes, and aeromagnetic anomalies and 2) to infer from this information the location of faults and continuity of rock units at these locations.

8.3.1.17.4.7.5 Activity: Evaluate surface geoelectric methods and plan potential applications of these methods within the site area

Objectives

The objectives of this activity are to 1) evaluate previous attempts to use surface geoelectric methods at the site, 2) evaluate technology currently available, 3) evaluate the potential contribution of these methods to definition of subsurface geometry of faults, 4) review potential applications of these methods to YMP needs, and 5) if appropriate, plan future applications of these methods at the site.

8.3.1.17.4.7.6 Activity: Evaluate methods to detect buried faults using gamma-ray measurements, and plan potential application of these methods within the site area

Objectives

The objectives of this activity are 1) to evaluate the feasibility of using surface and airborne gamma-ray measurements to detect and discriminate faults at the site, 2) to review potential applications of these methods to YMP needs, and 3) if appropriate, conduct an airborne radiometric survey for that purpose as an adjunct to the aeromagnetic survey of the site.

8.3.1.17.4.7.7 Activity: Evaluate thermal infrared methods and plan potential applications of these methods within the site area

Objectives

The objectives of this activity are to evaluate current thermal infrared survey technology, evaluate its potential application to remote mapping of fractures and faults at Yucca Mountain, review potential applications of these methods to YMP needs, and if appropriate, plan future applications of these methods at the site.

8.3.1.17.4.7.8 Activity: Evaluate shallow seismic reflection (mini-sosie) methods and, if appropriate, conduct surveys of selected structures at and proximal to the site area

Objectives

The objectives of this activity are to evaluate the subsurface configuration of selected Quaternary faults and the lateral continuity and inclination of key beds within the Miocene volcanic sequence at the northeastern, eastern, and southwestern parts of the site area.

8.3.1.17.4.8 Study: Stress field within and proximal to the site area

Objectives

The primary objective of this study is to provide data on the ambient stress at the site and its immediate vicinity that will aid in evaluating 1) the most favored orientation and nature of future movement on faults within the site area, 2) the stability of potential pathways for radionuclide travel controlled by or related to fracture aperture, 3) the stability of mined excavations, 4) the response of the rock mass to thermal loading, and 5) the applicability of tectonic models. A secondary objective is to evaluate the potential relevance of paleostress data to prediction of future stress orientations.

Rationalization of the stress and stain at the site in relation to the plate-tectonic setting and applicable tectonic models will be performed in Study 8.3.1.17.4.12 (regional tectonic models and synthesis). In situ stress determinations will also be made in the ESF. Refer to Activity 8.3.1.4.3.1.1 for a description of these tests. Paleostress indicators in the form of fractures and slickenside lineations will also be evaluated in the ESF. Refer to Activity 8.3.1.4.2.2.4 for a description of this activity.

8.3.1.17.4.8.1 Activity: Evaluate present stress field within the site area

Objectives

The objective of this activity is to measure the vertical and lateral variation of in situ stress at the site. These measurements will include the variation of in situ stress within the vicinity of the steep

hydrologic gradient in the northwestern section of the site area, and in one borehole that is expected to intersect a postulated detachment fault and subjacent Paleozoic rocks below Yucca Mountain.

8.3.1.17.4.8.2 Activity: Evaluate and test shallow borehole hydrofrac and triaxial strain recovery methods for the determination of in situ stress, and if appropriate, plan potential application of these methods within and proximal to the site

Objectives

The objectives of this activity are to

1. Evaluate the usefulness of shallow borehole hydrofrac and triaxial strain recovery methods for the determination of in situ stress.

2. Measure the lateral variation of in situ stress in areas proximal to the site.

3. Measure vertical variation in stress above and below the possible detachment between Miocene and Paleozoic rocks east of Yucca Mountain in the Little Skull Mountain or Striped Hills area.

8.3.1.17.4.8.3 Activity: Evaluate published and unpublished data on paleostress orientation at and proximal to the site and assess the relevance of these data to Quaternary tectonics

Objectives

The objective of this activity is to establish successive orientations of principal horizontal components of stress in the vicinity of Yucca Mountain to evaluate the stability of stress through time and to provide a partial basis for determining the duration of the contemporary tectonic framework.

8.3.1.17.4.8.4 Activity: Evaluate theoretical stress distributions associated with potential tectonic settings (wrench fault, normal fault, detachment fault setting, etc.) of the site

Objectives

The objectives of this activity are 1) to evaluate possible three- dimensional orientations of stress trajectories associated with potential tectonic settings of Yucca Mountain, including wrench fault, normal fault, and detachment fault tectonic models; 2) to evaluate the degree to which in situ stress data from Yucca Mountain and vicinity constrains applicability of these tectonic models to neotectonics of the site; and 3) to evaluate the potential relation between fracture aperture and in situ stress at Yucca Mountain.

8.3.1.17.4.9 Study: Tectonic geomorphology of the Yucca Mountain region

Objectives

The objectives of this study are 1) to document the magnitude of Quaternary uplift and subsidence within the Yucca Mountain region and 2) to evaluate regional variation in the nature and intensity of Quaternary faulting.

8.3.1.17.4.9.1 Activity: Evaluate age and extent of tectonically stable areas at and near Yucca Mountain

Objectives

The objective of this activity is to evaluate the age and areal distribution of surfaces that appear to have been tectonically stable at and near Yucca Mountain through determination of the distribution and age of surfaces with substantial coatings of desert varnish.

8.3.1.17.4.9.2 Activity: Evaluate extent of areas of Quaternary uplift and subsidence at and near Yucca Mountain

Objectives

The objectives of this activity are to

1. Identify areas of rapid uplift by comparing volume of fan with the area of the associated drainage basin.

2. Identify areas of Quaternary subsidence and uplift, including Amargosa Desert, Crater Flat, Fortymile Wash, Rock Valley, and Ash Meadows, through an analysis of fluvial history of the Amargosa drainage system.

3. Complete a study of average or general rates of erosion and dissection in the southern Great Basin province.

8.3.1.17.4.9.3 Activity: Evaluate variations in the nature and intensity of Quaternary faulting within 100 km of Yucca Mountain through morphometric and morphologic analysis

Objectives

The objectives of this activity are to

1. Define morphotectonic domains in the area within 100 km of Yucca Mountain and relate them to areal variation in intensity or nature of faulting.

2. Improve the definition of morphologic indicators of shallow detachment faulting, wrench faulting, and basin-range type normal faulting, and to use those indicators to characterize the nature of faulting in morphotectonic domains within 100 km of Yucca Mountain.

3. Constrain tectonic models applicable to the site through evaluation of regional patterns of Quaternary deformation as expressed by distribution of morphotectonic domains.

8.3.1.17.4.10 Study: Geodetic leveling

The primary objective of this study is to evaluate possible historical and contemporary vertical displacements across potentially significant Quaternary faults within 100 km of Yucca Mountain. A secondary objective is to characterize the historical rate of uplift and subsidence in the Yucca Mountain region, and evaluate the possible existence of tectonic boundaries, coinciding perhaps with the Walker Lane or with the Furnace Creek fault zone, that may separate domains with differing rates of uplift and subsidence.

Data developed in this study will be used in Study 8.3.1.17.4.12 (tectonic models and synthesis) to limit estimates of strain rates and contemporary fault displacements within 100 km of Yucca Mountain.

8.3.1.17.4.10.1 Activity: Relevel base-station network, Yucca Mountain and vicinity

Objectives

The objectives of this activity are 1) to evaluate the historic vertical displacement across potentially significant Quaternary faults and 2) to establish the locations and rates of uplift during historical times through measurement of the change in altitude of benchmarks since the last survey.

8.3.1.17.4.10.2 Activity: Survey selected base stations, Yucca Mountain and vicinity, using global positioning satellite

Objectives

The objective of this activity is to evaluate contemporary vertical displacement across potentially significant Quaternary faults and the contemporary rate of uplift and subsidence within 100 km of the site on the basis of altitude and position of selected base stations.

8.3.1.17.4.10.3 Activity: Analyze existing releveling data, Yucca Mountain and vicinity

Objectives

The objective of this activity is to evaluate historical vertical displacement across potentially significant Quaternary faults, and possible historic uplift and subsidence within 100 km of Yucca Mountain through detection of changes in altitude as recorded by existing leveling data.

8.3.1.17.4.11 Study: Characterization of regional lateral crustal movement

The objective of this study is to evaluate rates and orientations of historical and current lateral crustal movement based on analysis of existing data on seismicity, historical fault offset, and creep in the Basin and Range province.

Results of the evaluation will be used in Study 8.3.1.17.4.12 (tectonic models and synthesis) to constrain tectonic models applicable to Quaternary tectonics of the site, and in Study 8.3.1.17.4.1 (historical and current seismicity) to constrain probabilistic models of seismicity within 100 km of Yucca Mountain.

8.3.1.17.4.11.1 Activity: Analyze lateral component of crustal movement based on historical faulting, seismicity, and trilateration surveys

Objectives

The objective of this activity is to evaluate rates and orientation of historical and current crustal strain in the Basin and Range province and the Yucca Mountain region.

8.3.1.17.4.12 Study: Tectonic models and synthesis

The objectives of this study are 1) to synthesize data relevant to tectonics, 2) to develop a model or range of models that establishes the causal relation between application of tectonic forces and formation of structures observed at Yucca Mountain and vicinity, 3) to link observed rates of formation of those structures with regional rates of crustal strain, 4) to forecast changes in tectonic setting and the manner in which those changes will affect both the regional crustal strain rate and tectonic stability in the Yucca Mountain region, 5) to estimate the effect of those changes on rate and nature of crustal strain at Yucca Mountain and vicinity, and 6) to estimate the future rate of tectonic processes at Yucca Mountain.

8.3.1.17.4.12.1 Activity: Evaluate tectonic processes and tectonic stability at the site

Objectives

The objectives of this activity are to

1. Synthesize gravity studies at Yucca Mountain and vicinity, and define regional variations in mass, and attribute them, as appropriate, to variations in crustal thickness, degree of melting, shallow intrusions, distribution of specific stratigraphic units, and faults.

2. Synthesize magnetic studies at Yucca Mountain and vicinity, and define areal variations in magnetic field, and relate them as appropriate to distribution of specific stratigraphic units, shallow intrusions, and subsurface configuration of faults.

3. Evaluate the regional extent of detachment faults, wrench faults, volcanic rocks belonging to the Death Valley-Pancake Range belt, evaluate the regional pattern of oroclinal bending (oroflexing), evaluate the regional extent of Miocene ash-flow tuffs and associated pyroclastic and epiclastic rocks, and evaluate regional extent of Paleozoic rocks known to be aquifers, aquitards, or to provide favored surfaces of detachment or thrusting.

4. Synthesize and evaluate information pertaining to Quaternary wrench faulting in the Walker Lane (Las Vegas to Cedar Mountain), constrain, if possible, the rate of offset and recurrence interval of potentially significant faults (including the Bare Mountain fault and faults analogous to those near Cedar Mountain), and evaluate the applicability of this information to geologic hazards at the site.

5. Synthesize and evaluate information pertaining to detachment faults at Yucca Mountain and vicinity, and constrain, if possible, the rate of displacement, subsurface configuration, and character of risk posed by this class of faults.

6. Synthesize and evaluate information pertaining to normal (and north-trending oblique and strike-slip faults) at the site and vicinity, and constrain, if possible, aggregate strain rate, subsurface configuration, recurrence interval, and character of risk posed by this class of faults.

7. Synthesize and evaluate information pertaining to the northeast-trending left-lateral strike-slip faults at the NTS and vicinity, and constrain, if possible, slip rate, recurrence interval, and character of risk posed by this class of fault.

8.3.1.17.4.12.2 Activity: Evaluate tectonic models

Objectives

The objectives of this activity are to

1. Formulate a range of tectonic models that relate the nature and estimated rates (including bounding values of those estimated rates) of Quaternary processes (volcanism, faulting, uplift

and subsidence, lateral strain, and possibly folding) of potential significance to design and performance of the repository at Yucca Mountain.

2. Evaluate temporal changes in tectonic activity and resulting changes in fractures and other structural features of potential hydrologic significance at and in the vicinity of Yucca Mountain. Relate tectonic cycle, if it exists, to tectonic model(s).

3. Ensure that assumptions, inferences, and conclusions concerning tectonic processes that are important to design and performance of the repository are consistent with tectonic models applicable to the site.

4. Ensure that uncertainty in the data, assumptions, and inferences concerning rates and nature of those tectonic processes that are important to design or performance of the repository is adequately reflected in conclusions about those processes.

8.3.1.17.4.12.3 Activity: Evaluate tectonic disruption sequences

Objectives

The objective of this activity is to evaluate disruption sequences involving faulting, folding, uplift and subsidence, and volcanism that are of potential significance to design or performance of the repository.

8.3.1.18 Objectives of the Seal material properties development program (SCP Section 8.3.3.2)

8.3.1.18.1 Study 1.12.2.1 Seal material properties development

8.3.1.18.1.1 Activity 1.12.2.1.1: Detailed property determination of cementitious-based and earthen materials

Objectives

The objective of this activity is to initiate laboratory testing to determine material properties for sealing elements needed to resolve this issue.

8.3.1.18.1.2 Activity 1.12.2.1.2: Hydraulic conductivity and consolidation testing of crushed tuff

Objectives

The objective of this activity is to establish the hydraulic conductivity and consolidation behavior of crushed tuff to support the development of criteria for ramp and shaft fill and drift backfill.

8.3.1.19 Objectives of the postemplacement near-field environment program (SCP Section 8.3.4.2.4)

Objectives

To ensure that interactions with the emplacement environment do not compromise the function of the waste packages, the composition of water that may contact the waste packages, the amount of water that may contact the waste packages, and the emplacement hole stability must be established. To provide this information in a form that will allow evaluation of the attributes of the near-field environment, it is necessary to establish within limits the chemical and physical characteristics of the interactive elements in the repository.

8.3.1.19.1 Study 1.10.4.1: Characterize chemical and mineralogical changes in the postemplacement environment (SCP Section 8.3.4.2.4.1)

The objective of this study is to establish, to the degree required in Performance Issues 1.4 and 1.5 (Sections 8.3.5.9 and 8.3.5.10), the compositional features of water that may contact the waste packages. To accomplish this objective, it is necessary to determine the effects of chemical reactions on the rock-water system of the repository horizon over a range of temperatures and chemical conditions that bound the postclosure waste package environment. Seven activities are planned to collect the data needed for this study.

8.3.1.19.1.1 Activity 1.10.4.1.1: Rock-water interactions at elevated temperatures

Objectives

The objective of this activity is to establish the identity and abundance of reaction products that form during hydrothermal interaction of tuff and reference ground water at elevated temperatures.

8.3.1.19.1.2 Activity 1.10.4.1.2: Effect of grout, concrete, and other repository materials on water composition

The objectives of this activity were intentionally omitted; the scope of work is covered in Section 8.3.1.19.5.1.

8.3.1.19.1.3 Activity 1.10.4.1.3: Composition of vadose water from the waste package environment

Objectives

The objective of this activity is to characterize the composition of vadose water in the unsaturated, preemplacement waste package environment.

8.3.1.19.1.4 Activity 1.10.4.1.4: Dissolution of phases in the waste package environment

Objectives

The objective of this activity is to determine the dissolution kinetics of the phases present in the waste package environment.

8.3.1.19.1.5 Activity 1.10.4.1.5: Effects of radiation on water chemistry

Objectives

The objective of this activity is to determine the composition of water in the presence of a radiation field under postemplacement conditions.

8.3.1.19.1.6 Activity 1.10.4.1.6: Effects of container and borehole liner corrosion products on water chemistry

Objectives

The objectives of this activity were intentionally omitted; the scope of work is covered in Section 8.3.1.19.5.2.

8.3.1.19.1.7 Activity 1.10.4.1.7: Numerical analysis and modeling of rock-water interaction

Objectives

The objective of this activity is to examine effects and processes in natural systems for time periods and chemical conditions not duplicated by laboratory studies.

8.3.1.19.2 Study 1.10.4.2: Hydrologic properties of waste package environment (SCP Section 8.3.4.2.4.2)

The objectives of this study are to establish the hydrologic properties of the near-field repository rock and the effect of thermal perturbation on these hydrologic properties, over the range of anticipated postemplacement conditions. This study will establish the conditions under which fracture flow will predominate over matrix flow and will determine the relative hydrologic importance of gas versus liquid-phase transport under isothermal and polythermal conditions appropriate for the waste package environment. This study will also determine the degree to which thermal effects will modify the ambient hydrologic properties. Isothermal components will provide input for simulation of conditions during the controlled release period and provide partial validation for nonisothermal codes.

8.3.1.19.2.1 Activity 1.10.4.2.1: Single-phase fluid system properties

Objectives

The objectives of this activity are

1. To establish the single-fluid-phase hydrologic properties of fractured and unfractured tuff under isothermal conditions.

2. To establish the single-fluid-phase hydrologic properties of fractured and unfractured tuff in a thermal gradient.

8.3.1.19.2.2 Activity 1.10.4.2.2: Two-phase fluid system properties

Objectives

The objectives of this activity are

1. To establish the two-phase hydrologic properties of tuff under isothermal conditions.

2. To establish the two-phase hydrologic properties of tuff in a thermal gradient.

8.3.1.19.2.3 Activity 1.10.4.2.3: Numerical analysis of flow and transport in laboratory systems

Objectives

The objective of this activity is to use laboratory-scale tests for initial development and validation of the flow and transport code.

8.3.1.19.3 Study 1.10.4.3: Characterization of the geochemical attributes of the waste package environment (SCP Section 8.3.4.2.4.3)

The objectives of this study are to establish the geomechanical attributes of the waste package environment host rock. The need for this information is discussed in Section 7.4.1.1 and 7.4.1.2. The geomechanical studies will examine the geomechanical response of the near-field rock to the engineering and thermal regimes resulting from development of the repository and emplacement of the waste packages. The geomechanical properties determine the extent to which borehole wall failure can be expected to load the waste package containers. If alternative waste package emplacement modes are considered in Advanced Conceptual Design, the study will address the extent to which geomechanical behavior of the surrounding rock can load the waste package containers.

8.3.1.19.3.1 Activity 1.10.4.3.1: Block stability analysis

This analysis will provide information on the potential for impact and static loads on the waste package caused by the movement of rock blocks along pre-existing fractures.

8.3.1.19.3.2 Activity 1.10.4.3.2: Borehole damage analysis

This analysis will provide information on the potential for static loads on the waste package and for radionuclide release caused by spalling or borehole breakup.

8.3.1.19.3.3 Activity 1.10.4.3.3: Geomechanical properties analysis

This analysis will provide information on the nature of changes in the geomechanical properties of the rock in the near-field environment and how these changes will affect the performance of the waste package and EBS over the lifetime of the repository.

8.3.1.19.4 Study 1.10.4.4: Engineered barrier system field tests (SCP Section 8.3.4.2.4.4)

The laboratory tests described in Activities 1.10.4.1.1 through 1.10.4.1.7 (Sections 8.3.4.2.4.1.1 through 8.3.4.2.4.1.7) and 1.10.4.2.1 through 1.10.4.2.3 (Sections 8.3.4.2.4.2.1 through 8.3.4.2.4.2.3) require validation through in situ field tests in the repository horizon to establish the applicability of the laboratory studies to the repository block. These tests will be conducted in the exploratory studies facilities at the repository horizon. The activities listed below indicate the objectives of the work to be completed and the parameters TBD. Detailed descriptions of the activities will be available when the indicated test plans are completed. The work described in these activities addresses needs described in Sections 7.4.1.1., 7.4.1.5, and 7.4.1.6. The three activities in this study are described in the following sections.

Before initiation of the in situ tests that support this study, prototype tests to develop and validate the test procedures and protocols are planned. The prototype tests are designed to simulate the test conditions and evaluate the installation procedures and performance characteristics of the instrumentation planned for the in situ tests to be deployed in the Yucca Mountain ESF.

8.3.1.19.4.1 Activity 1.10.4.4.1: Repository horizon near-field hydrologic properties

Objectives

The objective of this activity is to determine the in situ hydrologic properties of rock in the repository horizon under thermally perturbed conditions.

8.3.1.19.4.2 Activity 1.10.4.4.2: Repository horizon rock-water interaction

Objectives

The objective of this activity is to determine the effect on water chemistry of thermal perturbation of the near-field environment.

8.3.1.19.4.3 Activity 1.10.4.4.3: Numerical analysis of fluid flow and transport in the repository horizon near-field environment

Objectives

The objective of this activity is to validate and calibrate fluid flow, temperature, and transport models by using waste-package-scale field studies.

8.3.1.19.5 Study 1.10.4.5: Characterize the effects of man-made materials on water chemistry in the postemplacement environment (8.3.4.2.4.5)

The objective of this study is to establish, to the degree required in Performance Issues 1.4 and 1.5 (Sections 8.3.5.9 and 8.3.5.10), the impacts of man-made materials on the compositional features of water that may contact the waste packages. To accomplish this objective, it is necessary to determine the effects of man-made materials over a range of temperatures and chemical conditions that bound the postclosure waste package environment. Four activities are planned to collect the data needed for this study.

8.3.1.19.5.1 Activity 1.10.4.5.1: Effect of grout, concrete, and other repository materials on water composition

Objectives

The objective of this activity is to test the rock-water interaction in the presence of concretes, grouts, EBS materials (other than the container and borehole liner), and other repository materials (Section 8.3.3) when the identity of the other materials is established. The objective of these tests is to determine if the proposed material satisfies the requirements specified in the performance allocation for this issue relating to effects of engineered barriers, shafts, and seals on water chemistry. The parameters and laboratory methods appropriate to this activity will be established when the other materials are identified.

8.3.1.19.5.2 Activity 1.10.4.5.2: Effects of container and borehole liner corrosion products on water chemistry

Objectives

The objective of this activity is to determine the effect of corrosion products on the composition of water in the package environment.

8.3.1.19.5.3 Activity 1.10.4.5.3: Effects of man-made materials in presence of radiation field

Objectives

The objective of this activity is to determine the effects of man-made materials on the composition of water in the presence of a radiation field under postemplacement conditions.

8.3.1.19.5.4 Activity 1.10.4.5.4: Numerical analysis and modeling of man-made material/water interaction

Objectives

The objective of this activity is to examine effects and processes for time periods and chemical conditions not duplicated by laboratory studies.

8.3.2 REPOSITORY PROGRAM

8.3.2.1 Overview

Section 8.3.2 presents the performance allocation tables for four repository design issues in the following subsections:

8.3.2.2 Configuration of the Underground Facilities
8.3.2.3 Repository Design Criteria for Radiological Safety
8.3.2.4 Nonradiological health and safety
8.3.2.5 Preclosure design and technical feasibility

8.3.2.2 Performance Allocation Tables for Configuration of the Underground Facilities

The postclosure design criteria of 10 CFR 60.133 require that the underground facility and EBS be designed to

1. Contribute to containment and isolation.

2. Assist the geologic setting in meeting performance objectives.

3. Take into account the thermal and thermomechanical response and the need for sufficient flexibility to accommodate site-specific conditions.

The four functions that the postclosure waste disposal System Element 2.0 (postclosure waste disposal system) must perform are given in the following list together with the regulatory section they address. These functions were selected so that there is a direct correlation between the functions and the postclosure design criteria as expressed in 10 CFR 60.133.

1. Select orientation, geometry, layout, and depth of the underground facility to contribute to containment and isolation, taking into account flexibility to accommodate site specific conditions (10 CFR 60.133(a)(1) and 10 CFR 60.133(b)).

2. Limit water usage and potential chemical changes during construction and operations of underground facility so as to not adversely affect performance of natural and engineered barriers following permanent closure (10 CFR 60.133(a)(1) and 10 CFR 60.133(h)).

3. Limit potential for excavation-induced changes in rock mass permeability during construction of the underground facility so as to not adversely affect performance of natural and engineered barriers following permanent closure (10 CFR 60.133(f)).

4. Design thermal loading taking into account performance objectives and thermomechanical response of host rock (10 CFR 60.133(i), 10 CFR 60.133(e)(2), and 10 CFR 60.133(h)).

In the following tables the specific processes contributing to each of the four functions are identified. Tables 8.3.2.2-1 through 8.3.2.2-4 provide performance measures, goals, and need confidence for each of the functions. Table 8.3.2.2-5 provides performance parameters and tentative goals for each performance measure in the first four tables.

8.3.2.3 Performance Allocation Tables for Repository Design Criteria for Radiological Safety

This issue addresses the features of the repository that relate to radiological safety. The regulatory bases for this issue arise primarily from two sources. First, 10 CFR Part 60 provides the repository design criteria in Sections 60.131 through 60.133. In addition, 10 CFR 60.111(a) and 10 CFR Part 20 are pertinent to this issue.

To allocate performance to the engineered systems of the Yucca Mountain MGDS, the functions of the MGDS with respect to this issue must be identified. These functions and what might be called subfunctions are listed below with some elaboration on each. The portion of 10 CFR 60.131 through 60.133 that the function or subfunction is intended to address is also listed in parentheses.

Function 1: Radiological protection. The first function of the repository is to maintain radiation doses, levels, and concentrations of radioactive material in restricted areas within the limits specified in 10 CFR Part 20. This function is intended to produce a design that will protect the radiological health and safety of both the repository workers and the public. Radiological protection involves many activities; therefore, it has been subdivided into 11 subfunctions. These subfunctions are labeled with letters that correspond to the designators used in the performance goal and parameters tables presented later in this section and are as follows:

A. Limit concentration of radioactive materials in air (10 CFR 60.131(a)(1)).

B. Limit time required to perform work in the vicinity of radioactive materials (10 CFR 60.131(a)(2)).

C. Provide suitable shielding where necessary (10 CFR 60.131 (a)(3)).

D. Monitor and control the dispersal of radioactive contamination (10 CFR 60.131(a)(4)).

E. Control access to high radiation areas (10 CFR 60.131(a) (5)).

F. Provide radiation alarm systems for worker protection (10 CFR 60.131(a)(6)).

G. Monitor and control radioactive materials in repository effluents (10 CFR 60.132(c)).

H. Provide radiation alarm systems for repository effluents (10 CFR 60.131(a)(6)).

I. Provide safe handling and storage of waste whether awaiting emplacement or being retrieved (10 CFR 60.132 (a)).

Table 8.3.2.2-1. Performance measures, goals, and needed confidence for selecting orientation, geometry, layout and depth of underground facility (postclosure design function 1)[a] (page 1 of 3)

Process		Performance measure	Tentative goal	Needed confidence
Possible	Relied on			
Vary depth, dip, orientation and lateral extent of underground facility to provide host rock with favorable containment and isolation characteristics	Yes	Usable area: Is usable area adequate for 70,000 metric tons of uranium (MTU) of waste?	1-A[b] Area available >> area needed - >200 m overburden - stay in TSw2[c] - have disturbed zone stay >70 m above water table[d] - stay in primary area - areal power density (APD) <allowable far-field APD - probability <0.1 in 1,000 yr that >0.5% of waste packages will be breached by tectonic processes or events - offset from exploratory boreholes >15 m (cf. Issue 1.12)	High High Medium High Medium High High High
Select emplacement borehole orientation and design to limit potential for adverse effects	Backup	Performance measures as defined by Issues 1.1, 1.6, and 1.10 will be used as part of choosing borehole orientation[e]	1-B Performance goals as defined by Issues 1.1, 1.6, and 1.10 will be used as part of choosing borehole orientation	Medium
Limit the amount of water in contact with container to provide favorable isolation and containment environment	Yes	Regions of dehydration or condensation and drainage pattern	1-C Design subsurface facility so that convection and natural drainage is away from containers and so that goals of Issues 1.10 and 1.12 can be met[f]	High
Skip and isolate unfavorable areas	Yes	Ground quality (technical feasibility performance measure)	1-D Goals for determining technical feasibility of underground development considering local variability will be set by Issue 4.4	High

Table 8.3.2.2-1. Performance measures, goals, and needed confidence for selecting orientation, geometry, layout and depth of underground facility (postclosure design function 1)[a] (page 2 of 3)

Process: Possible	Process: Relied on	Performance measure		Tentative goal	Needed confidence
Skip and isolate unfavorable areas (continued)		Extent of change in	1-E	Emplace in ground that satisfies	
		- saturation		- average saturation: 75%[g]	High
				- local saturation <90%[g]	Low
		- water chemistry		- water chemistry requirements established in Issue 1.10[h]	Medium
		Distance from ground with unfavorable properties	1-F	Stay far enough away to satisfy goals of 1-E above[i]	Medium
Adjust thermal load to accommodate local conditions	Yes	Temperature (to limit potential for adverse geochemical, etc. effects on the host rock)	1-G	Goals (4-O, 4-P, 4-R, 4-U, and 4-V) for determining allowable temperatures are set as part of function 4 (Table 8.3.2.2-4) of this issue	High
		Postclosure rock movements within acceptable limits under thermal loads	1-H	Goals (4-Q and 4-W) for determining if rock meets postclosure thermomechanical criteria will be set by function 4 (Table 8.3.2.2-4) of this issue	Medium

[a]The issues referenced in this table and its footnotes are addressed in the following sections: Issue 1.1 (total system performance, Section 8.3.5.13), Issue 1.6 (ground-water travel time, Section 8.3.5.12), Issue 1.10 (waste package characteristics-postclosure, Section 8.3.4.2), Issue 1.12 (seal characteristics, Section 8.3.3.2), and the climate program (Section 8.3.1.5).

[b]1-A indicates function 1 and goal A. This designator is carried over to Table 8.3.2.2-5 to associate data of that table with goals of this table.

[c]Goal is to stay in the TSw2 unit (low lithophysal Topopah Spring Member), but TSw1 (lithophysal Topopah Spring) may be considered. See Chapter 2 for complete description of units.

[d]The distance from the disturbed zone to the water table should be 70 m or more; preferably this should be 70 m of CHn (Calico Hills nonwelded unit).

[e]Design factors that will be considered in performance review of borehole orientation include drift size, extraction ratio, standoff distance, potential fault/fracture effects, borehole hydrology, liner effects, potential abnormal conditions, etc.

Table 8.3.2.2-1. Performance measures, goals, and needed confidence for selecting orientation, geometry, layout and depth of underground facility (postclosure design function 1)[a] (page 3 of 3)

Footnotes (continued)

[f]Specific requirements of Issue 1.12 include (1) locate surface portals in nonflood prone areas; (2) restrict the number of shafts and ramps; (3) retain capability to emplace seals at base of shafts; (4) provide adequate storage capacity at base of shafts; (5) grade drifts to drain away from emplacement areas; (6) ensure drift floors can be reconditioned to enhance drainage; (7) provide adequate storage at low point of subsurface facilities before water enters emplacement drifts; and (8) establish drainage of shops, etc., toward exploratory shaft 1 (ES-1) and men and material (MM) shafts and of emplacement areas away from ES-1 and MM shafts. Specific requirements of Issue 1.10 include keeping containers dry through drainage and maintaining temperatures greater than the boiling point of water for more than 300 yr.

[g]Goal is to emplace waste in areas consistent with Issue 1.1 by requiring average emplacement saturation to be about 75% or less and local saturation around emplacement boreholes to be less than 90%. Intent of goal is to assure that perturbations to the site due to construction, operations, and the addition of heat will not cause saturated conditions.

[h]Water chemistry goals as set by Issue 1.10. Conditions should not be disturbed from predevelopment conditions by more than a specified amount.

[i]Actual standoff is determined by conditions around the ground with unfavorable properties by requiring that goal 1-E be met. Faults are explicitly incorporated into the design through goals 1-A, however, the anomalous conditions of concern in goal 1-E (saturation and geochemistry) are most likely to occur near faults. During conceptual design the offset of Ghost Dance (approximately 14 m) was used to estimate how much bigger the layout would be if such a standoff were incorporated (SCP-CDR Appendix M (SNL, 1987)). If ground with unfavorable properties is found within the ESF, a better estimate (than offset) of appropriate standoff can be made.

Table 8.3.2.2-2. Performance measures, goals, and needed confidences for limiting water usage and potential chemical changes (postclosure design function 2)

Process		Performance measure		Tentative goal	Needed confidence
Possible	Relied on				
Limit adverse chemical changes by using acceptable materials and fluids	Yes	Type, quantity, and location of materials (including materials for seals):	2-I[a]	Requirements specified by Issues 1.10 and 1.12 (Sections 8.3.4.2 and 8.3.3.2) applied here	
		Quantity of concrete		Limit cement in emplacement boreholes and drifts to that required for proper construction[b]	Medium
		Quantity of shotcrete		Limit shotcrete in drift and access linings to that required for proper construction	Medium
		Quantity of grout for bolt anchors		Limit grout used for bolt anchors to that required for proper construction	Medium
		Quantity of organics		Limit organics in drilling fluids and explosive residues from blasting	High
Limit the amount of water used in construction, operation, emplacement of seals, and decommissioning to provide favorable containment and isolation environment	Yes	Net water from operations that remains in host rock at emplacement	2-J	Water usage should be limited so that saturation at emplacement does not violate goal 1-E, Table 8.3.2.2-1	High
				Limit water to that required for dust control and proper equipment function	
				Remove all excess water	

[a]2-I indicates function 2 and goal I. This indicator is carried over to Table 8.3.2.2-5 to associate data of that table with goals of this table.

[b]Quantities and chemical composition may be impacted by requirements related to postclosure performance objective for the waste package.

Table 8.3.2.2-3. Performance measures, goals, and needed confidences for limiting potential for excavation-induced changes in rock mass permeability (postclosure design function 3)

Process: Possible	Process: Relied on	Performance measure		Tentative goal	Needed confidence
Limit magnitude and extent of blast-induced permeability change by blast control	Backup	Permeability change due to blasting should not cause a change in disturbed zone boundary or unnecessarily complicate seal evaluation and emplacement	3-K[a]	Permeability change beyond 3 m should be less than one order of magnitude[b] (cf. Issue 1.6 (Section 8.3.5.12))	Medium
Limit potential for subsidence by limiting extraction ratio and drift size	Backup	Extraction ratio	3-L	Current design basis - Horizontal emplacement <10% - Vertical emplacement <30%	 High High
		Drift spans	3-M	<11 m	High
Backfill drifts at decommissioning	Backup	Amount of fill	3-N	Backfill to within 0.5 m of roof	Medium

[a]3-K indicates function 3 and goal K. This designator is carried over to Table 8.3.2.2-5 to associate data of that table with goals of this table.

[b]Drifts and emplacement boreholes; for description of constraints on shafts or seal areas see Issue 1.12 (Section 8.3.3.2).

Table 8.3.2.2-4. Performance measures, goals, and needed confidences for designing thermal loading taking into account performance objectives and thermomechanical response of host rock (postclosure design function 4) (page 1 of 2)

Process		Performance measure	Tentative goal	Needed Confidence
Possible	Relied on			
Limit temperature changes in selected barriers	Backup	Temperature	4-O[a] Limit temperature of CHn to <115C°[b]	Medium
			4-P Limit temperature of TSw3 to <115°[b]	Medium
Limit deleterious rock movement or preferred pathways	Backup	Potential for significant displacement (see Issue 1.1)	4-Q Relative motion <1 m at the top of TSw1[c] - No intact rock failure[d] - No continuous joint slip[e]	Medium
Limit impact on surface environment	Backup	Temperature	4-R Rise in surface temperature less than 6C°[f]	Low
		Surface uplift	4-S Surface uplift less than 0.5 cm per year[g]	Low
Vary borehole and drift spacing to control thermal loading and container temperature	Yes	Thermal loading	4-T Design basis thermal loading less than allowable thermal loading[h]	High
		Borehole wall temperature[i]	4-U Temperature <275°C	High
		Rock mass temperature[j]	4-V Temperature at 1 m from borehole <200°C[k]	High
Limit potential for borehole collapse	Yes	Stress, deformation, factor of safety, and potential rock fall	4-W Boreholes that do not load container beyond limits imposed under Issue 1.10 (Section 8.3.4.2)[l]	High
Limit corrosiveness of container environment	Yes	Time container is above boiling temperature of water (Issue 1.10)	4-X Majority of borehole walls above boiling temperature of water for >300 yr[m]	High

[a]4-O indicates function 4 and goal O. This designator is carried over to Table 8.3.2.2-5 to associate data of that table with goals of this table.

[b]Calculated with mean properties. See Issue 1.6 (Section 8.3.5.12) for a discussion of disturbed zone and ba... for these goals.

Table 8.3.2.2-4. Performance measures, goals, and needed confidences for designing thermal loading taking into account performance objectives and thermomechanical response of host rock (postclosure design function 4) (page 2 of 2)

Footnotes (continued)

[c]Issue 1.1 requirement is that the relative motion of the rock be less than 1 m (Section 8.3.5.13). To provide confidence that the goal is met, Issue 1.11 provides the additional constraints under goal 1-Q.

[d]Unconsolidated material and disturbed zone excluded from intact rock failure criteria.

[e]Continuous joint slip from surface to disturbed zone or from disturbed zone to water table.

[f]Unit evaluation goal retained in performance allocation process. Further evaluation of this goal is planned.

[g]Unit evaluation natural analogue goal retained and converted to rate in performance allocation process.

[h]Allowable thermal loading (APD) will be determined by goals (o) through (s). Current design basis is "equivalent energy density" through 2,000 yr to 10 yr old average burnup spent fuel emplaced at 57 kW/acre (as per unit evaluation).

[i]Borehole wall temperature chosen so that spent fuel waste temperature will not exceed 350°C using current canister designs (cf. Issue 1.10).

[j]To ensure as-built facility does not violate bounds of properties investigated in license application and to limit the potential for adverse stress conditions due to high temperature thermal expansion of the rock.

[k]200°C at 1 m may be replaced with some other measure of the volume of rock that may exceed the bounds of temperature for which the rock properties were investigated for license application.

[l]Goal is that borehole calculations using average properties (rock and waste) and design basis geometry will result in stresses, deformations, and factors of safety that are indicative of stable conditions for the average package. This will imply reasonable confidence that the goal is met.

[m]Goal is that borehole calculations using average properties (rock and water) and design basis geometry will result in the majority of the borehole walls being above boiling for more than 300 yr. This will imply reasonable confidence that the goal is met.

Table 8.3.2.2-5. Performance parameters and tentative goals for Issue 1.11, configuration of underground facilities (postclosure)[a] (page 1 of 12)

Related function and performance goal[b,c]	Performance parameter	Modifier	Tentative goal[d]	Needed confidence	Expected value	Current confidence	Obtained from SCP section
1-A	Layout	Drawing of underground facility location	Dimensions accurate to ±3 m	Medium	Dimensions accurate to ±0.5 m[e]	Medium	8.3.2.5
	Topography	Contour map of primary area and extensions	Contours accurate to ±7.5 m	Medium	Contours accurate to ±3 m	Medium	8.3.1.14
		Contour map of areas with minimum overburden	Contours accurate to ±3 m	High	Contours accurate to ±3 m	Medium	8.3.1.14
	Elevation of unit contacts for positioning underground facility[f]	Structure contour maps on upper and lower contact of TSw2 in primary area and extensions	Contours accurate to ±30 m	Medium	Contours accurate to ±30 m	Low	8.3.1.4
		Structure contour map on lower contact of TSw2 in areas of minimum overburden	Contours accurate to ±10 m	High	Contours accurate to ±10 m[e]	Low	8.3.1.4
		Structure contour map on upper contact of TSw2 in areas of minimum ground-water travel time	Contours accurate to ±10 m	Medium	Contours accurate to ±10 m[e]	Low	8.3.1.4
	Water table elevation	Contour map of water table in primary area and extensions	Contours accurate to ±7.5 m	Medium	Contours accurate to ±7.5 m[e]	Medium	8.3.1.2

Table 8.3.2.2-5. Performance parameters and tentative goals for Issue 1.11, configuration of underground facilities (postclosure)[a] (page 2 of 12)

Related function and performance goal[b,c]	Performance parameter	Modifier	Tentative goal[d]	Needed	Expected value	Current confidence	Obtained from SCP section
1-A (continued)		Contour map of water table in areas with minimum ground-water travel time	Contours accurate to ±10 m	High	Contours accurate to ±10 m[e]	Medium	8.3.1.2
	Fault descriptions for positioning underground facility	Map of fault locations showing dip and displacement for primary area and extensions	Locations accurate to ±30 m[g]	High	Locations accurate to ±30 m	Medium	8.3.1.4
			Actual strike and dip ±10° for each fault	High	Average strike and dip ±10° for each fault[e]	Medium	8.3.1.4
			Displacement measurements accurate to ±2 m	Medium	Displacement measurements accurate to ±2 m[e]	Low	8.3.1.4
		Classification	Standard practice	Low	Standard practice	Low	8.3.1.4
		Recurrence time for 5 cm displacement	>1,000 yr	High	(h)	Low	8.3.1.8
	Exploratory borehole locations	Coordinates of position of boreholes	Coordinates accurate to ±3 m	High	Coordinates accurate to ±1 m[e]	Medium	8.3.3.2
1-B	Goals of Issues 1.1, 1.6, and 1.10	Performance objectives affected by emplacement borehole design	See Issues 1.1, 1.6, and 1.10	Not applicable	Not applicable	Not applicable	8.3.5.13, 8.3.2.12, 8.3.4.2
1-C	Hydrothermal model describing how moisture moves in host rock	Data of Issue 1.1	See Issue 1.1	High	(h)	Low	8.3.5.13

Table 8.3.2.2-5. Performance parameters and tentative goals for Issue 1.11, configuration of underground facilities (postclosure)[a] (page 3 of 12)

Related function and performance goal[b,c]	Performance parameter	Modifier	Tentative goal[d]	Needed confidence	Expected value	Current confidence	Obtained from SCP section
1-D	Results of rock mass classification work of Issue 4.4	Identification of acceptable rock mass classifications	See Issue 4.4	High	See Issue 4.4	Low	8.3.2.5
1-E 1-F	Saturation	During development around the excavations	<90%	High	65 to 85%	Low	8.3.1.2, 8.3.5.16
	Geochemistry	During development around the excavations	See Issue 1.10	Medium	See Issue 1.10	Low	8.3.1.3, 8.3.5.16
1-G	See function 4 for data required	Goal 1-G requires results of thermal calculations of function 4. Hence, data required (heat capacity, initial temperature, container output, etc.) are called for under that issue.					8.3.2.2
1-H	See function 4 for data required	Goal 1-H requires results of thermal calculations of function 4. Hence, data required (thermal properties, initial stress, strength, etc.) are called for under that issue.					8.3.2.2
2-I	Material inventory	Proposed inventory	See Issue 4.4	High	(h)	Low	8.3.2.5
	Geochemical effects	Effect of inventory	(i)	Medium	(h)	Low	8.3.4.2
2-J	Planned water usage	For mining operations	See Issue 4.4	High	(h)	Low	8.3.2.5
	Water usage in ESF	For mining operations	See Section 8.3.1.2	Medium	(h)	Low	8.3.1.2

Table 8.3.2.2-5. Performance parameters and tentative goals for Issue 1.11, configuration of underground facilities (postclosure)[a] (page 4 of 12)

Related function and performance goal[b, c]	Performance parameter	Modifier	Tentative goal[d]	Needed confidence	Expected value	Current confidence	Obtained from SCP section
	Goals of Issue 1.1	Allowable saturations	See Section 8.3.5.13	Medium	Not applicable	Not applicable	8.3.5.13
3-K	Excavation method	Proposed method	See Issue 4.4	Medium	See Issue 4.4	Medium	8.3.2.5
	Disturbed zone	Definition	See Section 8.3.5.12	Medium	Not applicable	Not applicable	8.3.5.12
	Blast-induced permeability change	Around excavations	±50% of in situ permeability	Medium	(h)	Low	8.3.1.15
3-L	Layout	Drawings of layout of underground facility	Dimensions accurate to ±0.5 m	High	Dimensions accurate to ±0.5 m	Medium	8.3.2.5
3-M	Layout	Excavation dimensions	Dimensions accurate to ±0.5 m	High	Dimensions accurate to ±0.5 m	Medium	8.3.2.5
3-N	Proposed backfill	Height of fill	Nonsite data	Medium	Nonsite data	NA	8.3.2.5
4-W	Peak ground acceleration from probability versus ground motion	For TSw2 in primary area and extensions	0.5 to 0.7g with >10,000-yr return period	Medium	(h)	Low	8.3.1.17
4-X 4-T 4-O 4-P 4-Q 4-R 4-S	Topography	Contour map of location of ground surface in primary area and extensions for use in thermal modeling	Contours accurate to ±30 m	Medium	Contours accurate to ±30 m	Medium	8.3.1.4

Table 8.3.2.2-5. Performance parameters and tentative goals for Issue 1.11, configuration of underground facilities (postclosure)[a] (page 5 of 12)

Related function and performance goal[b,c]	Performance parameter	Modifier	Tentative goal[d]	Needed confidence	Expected value	Current confidence	Obtained from SCP section
4-X 4-T 4-O 4-P 4-Q 4-R 4-S	Geologic structure to water table (location of faults for thermal modeling)	Map of location of faults in primary area and extensions for use in thermal modeling	Location accurate to ±150 m	Medium	Location accurate to ±150m[e]	Low	8.3.1.4
4-X 4-T 4-O 4-P 4-Q 4-R 4-S	Geologic stratigraphy to water table (location of unit contacts for thermal modeling)	Structure contour maps on upper and lower contacts of TSw2 in primary area and extensions	Contours accurate to ±30 m	Medium	Contours accurate to ±30 m	Low	8.3.1.4
		Structure contour map on lower contact of TSw2 in areas with minimum overburden	Contours accurate to ±10 m	Medium	Contours accurate to ±10 m[e]	Low	8.3.1.4
		Structure contour map on upper contact of TSw2 in areas with minimum ground-water travel time	Contours accurate to ±10 m	Medium	Contours accurate to ±10 m[e]	Low	8.3.1.4
		Structure contour map on upper and lower contacts of other units in primary area and extensions	Contours accurate to ±60 m	Medium	Contours accurate to ±60 m[e]	Low	8.3.1.4

Table 8.3.2.2-5. Performance parameters and tentative goals for Issue 1.11, configuration of underground facilities (postclosure)[a] (page 6 of 12)

Related function and performance goal[b,c]	Performance parameter	Modifier	Tentative goal[d]	Needed confidence	Expected value	Current confidence	Obtained from SCP section
4-U 4-V 4-W 4-X	Emplacement geometry	Drawing locating boreholes and containers	Dimensions accurate to ±30 cm	High	Dimensions accurate to ±30 cm	Medium	8.3.2.5
		Drawing locating drifts	Dimensions accurate to ±3 m	Medium	Dimensions accurate to ±3 m	Medium	8.3.2.5
4-U 4-S 4-V 4-X	Container thermal output	Thermal output as a function of waste age and burnup	Nonsite data[j,k]	Not applicable	Nonsite data	Not applicable	8.3.4.2
4-W 4-O 4-P 4-Q	Container dimensions	(k)	Nonsite data[k]	Not applicable	Nonsite data	Not applicable	8.3.4.2
4-T 4-R	Waste inventory	(k)	Nonsite data[k]	Not applicable	Nonsite data	Not applicable	8.3.4.2
4-U 4-S 4-V 4-X	Initial temperature for thermal modeling	Of TSw2 in primary area and extensions	Temperature accurate to ±3°C[l]	Medium	Temperature = 23°C to 26°C ± 1.5°C[e]	Medium	8.3.1.15
4-W 4-O 4-P 4-Q 4-T 4-R		Mean annual air temperature for primary area	Temperature accurate to ±3°C	Medium	Temperature = 16°C to ±1°C[e]	Medium	8.3.1.12
4-W 4-Q 4-S	Initial stress state for primary area and extensions	Vertical stress and magnitude and direction of minimum and maximum horizontal stress	Vertical stress[m] accurate to ± 1 MPa	Medium	Vertical stress = weight of overburden	Low to medium	8.3.1.15

Table 8.3.2.2-5. Performance parameters and tentative goals for Issue 1.11, configuration of underground facilities (postclosure)[a] (page 7 of 12)

Related function and performance goal[b,c]	Performance parameter	Modifier	Tentative goal[d]	Needed confidence	Expected value	Current confidence	Obtained from SCP section
			Horizontal stress[m] accurate to ±2 MPa	Low	Horizonal/vertical stress ratio = 0.3 to 1 for TSw2	Low	8.3.1.15
4-U 4-S 4-V 4-X 4-W 4-O 4-P 4-Q 4-T 4-R	Heat capacity	TSw2[n] <275°C	Current mean[o] ±10%	High	See Table 6-16	Low to medium	8.3.1.15
		TSw3 and CHn1[n] <115°C	Current mean[o] ±10%	Medium	See Table 6-16	Low to medium	8.3.1.15
		Below CHn1[p] <100°C	Current mean[o] ±10%	Low	See Table 6-16	Low	8.3.1.15
		TSw1[n] <275°C	Current mean[o] ±10%	Medium	See Table 6-16	Low to medium	8.3.1.15
		Above TSw1[p] <50°C	Current mean[o] ±10%	Low	See Table 6-16	Low	8.3.1.15
4-U 4-S 4-V 4-X 4-W 4-O 4-P 4-Q 4-T 4-R	Thermal conductivity	TSw2[n] <275°C	Current mean[o] ±20%	High	See Table 6-16	Low to medium	8.3.1.15
		TSw3 and CHn1[n] <115°C	Current mean[o] ±20%	Medium	See Table 6-16	Low to medium	8.3.1.15
		Below CHn1[p] <100°C	Current mean[o] ±20%	Low	See Table 6-16	Low to medium	8.3.1.15
		TSw1[n] <275°C	Current mean[o] ±20%	Medium	See Table 6-16	Low to medium	8.3.1.15
		Above TSw1[p] <50°C	Current mean[o] ±20%	Low	See Table 6-16	Low to medium	8.3.1.15

Table 8.3.2.2-5. Performance parameters and tentative goals for Issue 1.11, configuration of underground facilities (postclosure)[a] (page 8 of 12)

Related function and performance goal[b,c]	Performance parameter	Modifier	Tentative goal[d]	Needed confidence	Expected value	Current confidence	Obtained from SCP section
4-W 4-Q 4-S	Coefficient of thermal expansion	TSw2 <275°C	Current mean[e] ±15%	High	See Table 6-16	Medium	8.3.1.15
		TSw3 and CHn1 <115°C	Current mean[e] ±15%	Medium	See Table 6-16	Low to medium	8.3.1.15
		Below CHn1 <100°C	Current mean[e] ±15%	Low	See Table 6-16	Low to medium	8.3.1.15
		TSw1 <275°C	Current mean[e] ±15%	Medium	See Table 6-16	Low to medium	8.3.1.15
		Above TSw1 <50°C	Current mean[e] ±15%	Low	See Table 6-16	Low to medium	8.3.1.15
4-W 4-Q 4-S	Young's modulus	TSw2 for 0-100 MPa	Current mean[e] ±15%	High	See Table 6-12	Medium	8.3.1.15
		TSw3 and CHn1[g]	Current mean[e] ±15%	Medium	See Table 6-12	Low	8.3.1.15
		Below CHn1[g]	Current mean[e] ±15%	Low	See Table 6-12	Low to medium	8.3.1.15
		TSw1 for 0-100 MPa	Current mean[e] ±15%	Medium	See Table 6-12	Medium	8.3.1.15
		Above TSw1[g]	Current mean[e] ±15%	Low	See Table 6-12	Low to medium	8.3.1.15
4-W 4-Q 4-S	Deformation modulus	TSw2 for 0-100 MPa	Current mean[e] ±15%	High	See Table 6-14	Low	8.3.1.15
		TSw3 and CHn1[g]	Current mean[e] ±15%	Medium	See Table 6-14	Low	8.3.1.15
		Below CHn1[g]	Current mean[e] ±15%	Low	See Table 6-14	Low	8.3.1.15
		TSw1 for 0-100 MPa	Current mean[e] ±15%	Medium	See Table 6-14	Low	8.3.1.15
		Above TSw1[g]	Current mean[e] ±15%	Low	See Table 6-14	Low	8.3.1.15

Table 8.3.2.2-5. Performance parameters and tentative goals for Issue 1.11, configuration of underground facilities (postclosure)[a] (page 9 of 12)

Related function and performance goal[b,c]	Performance parameter	Modifier	Tentative goal[d]	Needed confidence	Expected value	Current confidence	Obtained from SCP section
4-W 4-Q 4-S	Poisson's ratio	TSw2 for 0-100 MPa	Current mean[o] ±20%	Medium	See Table 6-12	Medium	8.3.1.15
		TSw3 and CHn1[q]	Current mean[o] ±20%	Low	See Table 6-12	Low to medium	8.3.1.15
		Below CHn1[q]	Current mean[o] ±20%	Low	See Table 6-12	Low to medium	8.3.1.15
		TSw1 for 0-100 MPa	Current mean[o] ±20%	Low	See Table 6-12	Low to medium	8.3.1.15
		Above TSw1[q]	Current mean[o] ±20%	Low	See Table 6-12	Low	8.3.1.15
4-W 4-Q 4-S	Matrix unconfined compressive strength for units other than TSw2 and TSw1	In situ conditions and representative strain rate[r]	Current mean[o] ±20%	Medium	See Table 6-12	Low to medium	8.3.1.15
4-W 4-Q 4-S	Matrix angle of internal friction for units other than TSw2 and TSw1	In situ conditions and representative strain rate[r]	Current mean[o] ±20%	Medium	See Table 6-12	Low to medium	8.3.1.15
4-W 4-Q 4-S	Matrix cohesion for units other than TSw2 and TSw1	In situ conditions and representative strain rate[r]	Current mean[o] ±20%	Medium	See Table 6-12	Low to medium	8.3.1.15

Table 8.3.2.2-5. Performance parameters and tentative goals for Issue 1.11, configuration of underground facilities (postclosure)[a] (page 10 of 12)

Related function and performance goal[b,c]	Performance parameter	Modifier	Tentative goal[d]	Needed confidence	Expected value	Current confidence	Obtained from SCP section
4-W 4-Q 4-S	Rock compressive strength for TSw1 and TSw2	0-100 MPa and representative strain rate[f]	Current mean[o] ±20%	High	(h)	Medium	8.3.1.15
4-W 4-Q 4-S	Joint angle of internal friction for units other than TSw2 and TSw1	In situ conditions and representative strain rate	Current mean[o] ±15%	Medium	See Table 6-13	Low	8.3.1.15
4-W 4-Q 4-S	Joint cohesion for units other than TSw2 and TSw1	In situ conditions and representative strain rate	Current mean[o] ±15%	Medium	See Table 6-13	Low	8.3.1.15
4-W 4-Q 4-S	Large-scale joint strength for TSw1 and TSw2	0-30 MPa normal stress and representative strain rate	Current mean[o] ±20%	High	(h)	Low	8.3.1.15
4-Q 4-W	Joint normal stiffness	TSw2	See Table 6-13[s]	Medium	See Table 6-13[t]	Low	8.3.1.15
		TSw1, TSw3, and CHn1	See Table 6-13[s]	Low	See Table 6-13[t]	Low	8.3.1.15
	Joint sheer stiffness	TSw2	See Table 6-13[s]	Medium	See Table 6-13[t]	Low	8.3.1.15
		TSw1, TSw3, and CHn1	See Table 6-13[s]	Low	See Table 6-13[t]	Low	8.3.1.15
	Joint spatial orientation	TSw2	See Table 6-15[s]	Medium	See Table 6-15	Low	8.3.1.4
		TSw1, TSw3, and CHn1	See Table 6-15[s]	Low	See Table 6-15	Low	8.3.1.4

Table 8.3.2.2-5. Performance parameters and tentative goals for Issue 1.11, configuration of underground facilities (postclosure)[a] (page 11 of 12)

Related function and performance goal[b,c]	Performance parameter	Modifier	Tentative goal[d]	Needed confidence	Expected value	Current confidence	Obtained from SCP section
	Joint abundance	TSw2	See Table 6-15[e]	Medium	See Table 6-15	Low	8.3.1.4
		TSw1, TSw3, and CHn1	See Table 6-15[e]	Low	See Table 6-15	Low	8.3.1.4
	Joint persistence	TSw2	See Table 6-15[e]	Medium	See Table 6-15	Low	8.3.1.4
		TSw1, TSw3, and CHn1	See Table 6-15[e]	Low	See Table 6-15	Low	8.3.1.4
	Joint wall compressive strength	TSw2	See Table 6-15[e]	Medium	See Table 6-13	Low	8.3.1.15
		TSw1, TSw3, and CHn1	See Table 6-15[e]	Low	See Table 6-13	Low	8.3.1.15
	Joint roughness coefficient	TSw2	See Table 6-15[e]	Medium	See Table 6-13	Low	8.3.1.15
		TSw1, TSw3, and CHn1	See Table 6-15[e]	Low	See Table 6-13	Low	8.3.1.15

[a]Abbreviations used in this table are defined as follows: ESF = exploratory studies facility; TSw1 = lithophysal portion of Topopah Spring welded unit; TSw2 = low lithophysal portion of Topopah Spring welded unit (preferred thermomechanical emplacement unit); TSw3 = basal vitrophyre Topopah Spring; CHn1 = tuffaceous beds of Calico Hills. See Chapter 2 for more complete description of units.

[b]Goals are ranked in judged order of importance of data item to issue resolution.

[c]1-A indicates function 1 and goal A. This designator is used to associate data requirements of this table with goals of Tables 8.3.2.2-1 through 8.3.2.2-4.

[d]Current mean is value given in current reference information (Tables 6-11 through 6-16).

[e]Expected value based on judgement.

[f]Elevation of the contacts of the thermal/mechanical unit TSw2 determined using data that already exists plus data to establish the top and bottom of unit TSw2 at the following approximate locations: (1) Midpoint of western ridge; (2) Northern extension of primary area: a) N775000 - E559000, b) N772500 - E560500, c) N773500 - E563500; and (3) Southeast extension of primary area: a) N760500 - E563000, b) N758500 - E561000, c) N757000 - E560000; and also by reevaluating existing borehole data: (1) Drill Hole Wash series; (2) H Hole series. Further lateral drifting from exploratory shaft will be used to (1) confirm contact between TSw1 and TSw2; (2) confirm fault locations at underground facility depth (for 2 or 3 faults, as intersected by lateral drifts); (3) confirm fault offsets in current structural model; and (4) provide drifting construction experience in faulted welded tuff.

Table 8.3.2.2-5. Performance parameters and tentative goals for Issue 1.11, configuration of underground facilities (postclosure)[a] (page 12 of 12)

Footnotes (continued)

[g]Averaged across the site, not accuracy at a given point.
[h]Inadequate information exists to establish expected value, but it is anticipated that a value satisfying the goal will be obtained.
[i]Accuracy determined by Issue 1.10 (Section 8.3.4.2).
[j]Calculations done to resolve this issue are based on power as a function of time (initial power and normalized decay function). As long as standard deviations of initial value and decay coefficients are no more than ten percent, calculations done to determine if goals of this issue are met should be valid.
[k]See Information Need 1.11.2 (Section 8.3.2.2.2) for details and accuracy.
[l]Existing data should be sufficient. Temperature could be a function of position in unit TSw2.
[m]Calculations are based on a vertical stress determined from the weight of the overburden and a horizontal to vertical stress ratio (K_o = 0.3 to 0.8). Calculations done to determine if the goals of this issue are met should be valid if the stresses so calculated are within the tentative goal specified for the in situ stress. Note: the tentative goal specified for the in situ stress is an estimate; if it can be shown with reasonable assurance that the minimum K_o is greater than 0.2, a lower accuracy for the tentative goal would be acceptable.
[n]Mean and standard deviation as a function of saturation.
[o]If the in situ rock at representative conditions has a distribution of property values which have the required confidences such that an adequate portion of the samples fall within the range prescribed by the current mean and percentage (percentage given in the table), then the calculations done to determine if the goals are met should be valid. If the distribution of property values does not meet this condition, then (1) the calculations will have to be reevaluated, (2) the calculations will have to be redone with new property values, (3) the design will have to be changed, (4) the accuracy of the data will have to be improved, or (5) the goal will not be met. Representative conditions are appropriate values of one or more of the following: saturation, stress, temperature, fracture, or jointing characteristics, etc., averaged over a representative volume.
[p]Mean and standard deviation representative at in situ saturation.
[q]At in situ conditions.
[r]Property representative of the volume of rock between dominate jointing.
[s]Sensitivity studies evaluating parameter range and goal have not yet been performed.
[t]These parameters can be calculated from values in Table 6-13.

J. Provide repository facility ventilation systems that will protect against radiation exposure (10 CFR 60.132 (b) and 10 CFR 60.133 (g)).

K. Assure the continued function and separation of ventilation systems during normal operations and under accidents conditions (10 CFR 60.132(b) and 10 CFR 60.133(g)).

Function 2: Design and protection of structures, systems, and components ITS. This function is intended to produce a design that provides assurance that radiation safety design features will operate effectively when they are needed. This function also involves many activities and has been subdivided into eight subfunctions. These eight subfunctions are also labeled with the letter designators used later in this section and are as follows:

L. Protect structures, systems, and components ITS against natural phenomena and environmental conditions (e.g., rockburst) (10 CFR 60.131(b)(1)).

M. Protect structures, systems, and components ITS against dynamic effects of equipment failure and similar events (10 CFR 60.131(b)(2)).

N. Protect structures, systems, and components ITS against fires and explosions (10 CFR 60.131(b)(3)).

O. Ensure that structures, systems, and components ITS will maintain control of radioactive materials, permit prompt termination of operations, and allow evacuation of personnel during an emergency (10 CFR 60.131(b)(4)(i)).

P. Ensure that utilities ITS will continue their safety functions during emergencies (10 CFR 60.131(b)(5)).

Q. Ensure that structures, systems, and components ITS will facilitate inspection, testing, and maintenance (10 CFR 60.131(b)(6)).

R. Provide timely backup power when needed and during emergencies (10 CFR 60.131(b)(5)).

S. Provide instrumentation and control systems to monitor and control structures, systems, and components ITS for all anticipated ranges of operation (10 CFR 60.131(b)(8)).

Function 3: Criticality control. This function will provide assurance that all systems for processing, transporting, handling, storage, retrieval, emplacement, and isolation of radioactive material are designed to ensure that a criticality accident is not credible (10 CFR 60.131(b)(7)).

Function 4: Compliance with mining regulations. This function will ensure that requirements of 30 CFR Chapter I, Subchapters D, E, and N that are applicable to protection of workers who perform a safety function will be incorporated into the design of the repository (10 CFR 60.131(b)(9)).

Function 5: Waste treatment. This function will ensure that waste treatment facilities are designed to permit safe offsite disposal of site- generated waste in accordance with applicable regulations (10 CFR 60.132(d)).

After the identification of functional requirements, performance measures, performance goals, and needed parameters were developed. The results of these steps are in Tables 8.3.2.3-2 and 8.3.2.3-3. Performance measures developed for each function provide the means to measure success in performing the required functions. Performance goals were developed such that if the goals are met, the function is satisfactorily completed. The parameters listed in Table 8.3.2.3-3 for each performance goal are those site data needed to calculate the performance measure to be compared with the performance goal.

Table 8.3.2.3-2. Functions, performance measures, and performance goals for Issue 2.7 (repository design criteria for radiological safety) (page 1 of 13)

Subfunction	Process or activity	Performance measure	Tentative goal	Needed confidence	Site data?
			RADIOLOGICAL PROTECTION (FUNCTION 1)		
A Limit concentrations of radioactive materials in air	Monitor concentrations of radioactive materials in repository airstreams	Concentrations of radioactive materials in repository airstreams	A1 Concentrations of radioactive materials in normally occupied areas do not exceed 20% of the values listed in in 10 CFR 20, Appendix B, Table 1, Column 1	(a)	No
			A2 Concentrations of non-naturally occurring radioactive materials in controlled access areas do not exceed the values listed in 10 CFR 20, Appendix B, Table 1, Column 1	High	Yes
			A3 Concentrations of naturally occurring radon and short-lived radon daughters such that annual exposure is less than 4 Working Level Months as defined in 30 CFR 57.2	High	Yes
	Filter exhaust air from potentially contaminated areas	Concentrations of radioactive materials in repository airstreams	See A1, A2, and A3 above	High	Yes
	Maintain gaseous radionuclides in repository airstreams below acceptable levels	Concentrations of radioactive materials in repository airstreams	See A1, A2, and A3 above	High	Yes

Table 8.3.2.3-2. Functions, performance measures, and performance goals for Issue 2.7 (repository design criteria for radiological safety) (page 2 of 13)

Subfunction	Process or activity	Performance measure	Tentative goal	Needed confidence	Site data?
RADIOLOGICAL PROTECTION (FUNCTION 1) (continued)					
B Limit time required to perform work in the vicinity of radioactive materials	Limit time of occupancy for tasks in radiation fields greater than 0.5 mrem/h	Time required to perform tasks in radiation fields greater than 0.5 mrem/h	B1 Time limited such that the as low as reasonably achievable (ALARA) principle is met	(a)	No
			B2 Combined annual individual worker dose less than 1 rem by as much as reasonable	(a)	No
	Provide remote handling capability for long-term task in radiation fields greater than 0.5 mrem/h	Dose reduction due to use of remote handling equipment	B3 Dose reduction enough to justify use of remote handling equipment	(a)	No
C Provide suitable shielding materials	Provide shielding to reduce radiation fields to below 0.5 mrem/h in normally occupied work areas	Radiation fields in normally occupied work areas	C1 Radiation fields less than 0.5 mrem/h by as much as is reasonable	(a)	No
	Utilize shielding properties of the host rock in limiting exposure of workers to direct radiation	Dose reduction factor attributable to host rock shielding properties	C2 Dose reduction factor properties similar to concrete	Medium	Yes
D Monitor and control the dispersal of radioactive contamination	Monitor contamination by using				
	- Stationary radiation monitoring systems	Contamination levels outside contamination areas	D1 Doses due to contamination insignificant	(a)	No

Table 8.3.2.3-2. Functions, performance measures, and performance goals for Issue 2.7 (repository design criteria for radiological safety) (page 3 of 13)

Subfunction	Process or activity	Performance measure	Tentative goal	Needed confidence	Site data?
		RADIOLOGICAL PROTECTION (FUNCTION 1) (continued)			
D Monitor and control the dispersal of radioactive contamination (continued)	- Portable radiation monitors	Contamination levels outside contamination areas	D2 Doses due to contamination insignificant	High	Yes
	- Personnel dosimetry	Contamination on personnel	D3 Doses due to contamination insignificant	(a)	No
	Control dispersal of contamination by				
	- Providing access control to potential contamination areas	See subfunction E, performance measures	D4 See subfunction E, goals	(a)	No
	- Providing ventilation control and cleanup of airstreams	See subfunction J, performance measures	D5 See subfunction J, goals	High	Yes
	- Decontamination of contaminated items and equipment	Residual contamination	D6 Use Regulatory Guide 1.86 (NRC, 1974), methods and meet goals	(a)	No
	- Collection of site-generated waste	Residual contamination due to site-generated waste	D7 No residual contamination	(a)	No

Table 8.3.2.3-2. Functions, performance measures, and performance goals for Issue 2.7 (repository design criteria for radiological safety) (page 4 of 13)

Subfunction	Process or activity	Performance measure	Tentative goal	Needed confidence	Site data?
RADIOLOGICAL PROTECTION (FUNCTION 1) (continued)					
E Control access to high radiation areas	Provide signs and personnel barriers to prevent access by unauthorized personnel	Visibility of signs	E1 Compliance with 10 CFR 20.203	(a)	No
			E2 Adequate visibility	Medium	No
		Distribution and location of signs	E3 Compliance with 10 CFR 20.203	(a)	No
			E4 Adequate distribution	(a)	No
		Effectiveness of personnel barriers	E5 Adequate barrier effectiveness	(a)	No
	If necessary, provide guards to prevent access by unauthorized personnel	Effectiveness of guard	E6 No unauthorized access	(a)	No
	Provide procedural requirements to control access to high radiation areas	Effectiveness of procedures	E7 Adequate procedures to control access	(a)	No
F Provide radiation alarm systems for worker protection	Provide visual alarm systems to alert workers if radiation levels exceed established design levels	Visibility of alarm system	F1 Adequate visibility	(a)	No
		Accuracy and reliability of alarm system	F2 Adequate accuracy and reliability of alarm system	(a)	No

Table 8.3.2.3-2. Functions, performance measures, and performance goals for Issue 2.7 (repository design criteria for radiological safety) (page 5 of 13)

Subfunction	Process or activity	Performance measure	Tentative goal	Needed confidence	Site data?
RADIOLOGICAL PROTECTION (FUNCTION 1) (continued)					
F Provide radiation alarm systems for worker protection (continued)	Provide audible alarm systems to alert workers if radiation levels exceed established design levels	Loudness and noticeability of alarm system	F3 Consistency with Regulatory Guide 8.5 (NRC, 1981b)	(a)	No
		Accuracy and reliability of alarm system	F4 Adequate accuracy and reliability of alarm system	(a)	No
G Monitor and control radioactive materials in repository effluents	Detect radioactive materials in repository effluents streams	Ability to detect radioactive materials in repository effluent streams	G1 Adequate detection of significant radionuclides in repository effluents	(a)	No
			G2 Detection precision consistent with industry standard and adequate to demonstrate compliance with goals	(a)	No
	Control radioactive materials in repository effluent streams	Ability to control radioactive materials in repository effluent streams	G3 Adequate control of significant radionuclides in repository effluents	(a)	No
			G4 Maintain releases of radioactive materials at or below levels that would result in offsite individual 50-yr dose equivalents of 25 mrem/yr (see page 8.10 of ALARA guide; Kathren et al., 1980)	High	Yes
H Provide radiation alarm systems for repository effluents	Provide visual alarm systems to alert workers if radiation levels in effluents exceed established design levels	See subfunction F, performance measures	H1 See subfunction F, goals	(a)	No

Table 8.3.2.3-2. Functions, performance measures, and performance goals for Issue 2.7 (repository design criteria for radiological safety) (page 6 of 13)

	Subfunction	Process or activity	Performance measure		Tentative goal	Needed confidence	Site data?
			RADIOLOGICAL PROTECTION (FUNCTION 1) (continued)				
H	Provide radiation alarm systems for repository effluents (continued)	Provide audible alarm systems to alert workers if radiation levels in effluents exceed established design levels	See subfunction F, performance measures	H2	See subfunction F, goals	(a)	No
I	Provide safe handling and temporary storage of waste whether awaiting emplacement or being retrieved	See subfunction B, limit work time in vicinity of radioactive materials	See subfunction B, performance measures	I1	See subfunction B, goals	(a)	No
		See subfunction C, provide suitable shielding	See subfunction C, performance measures	I2	See subfunction C, goals	High	Yes
		Maintain combined individual worker doses from all sources of radiation below annual design objective	Combined annual individual worker doses from all sources of radiation	I3	Combined annual individual worker doses from all sources of radiation less than 1 rem and ALARA	(a)	No
J	Provide repository facility ventilation systems that will protect against radiation exposure	Maintain airflow in direction from areas of lower contamination potential to areas of higher contamination potential	Pressure differentials between radiation zones	J1	Between 0.1 and 0.5 in. WG	High	Yes
			Potential for accidental flow reversals	J2	Accidental flow reversal precluded	(a)	No
			Flow rate in highly contaminated areas	J3	Adequate room changes per hour in areas of highest contamination per hour (e.g., isolation zones and hot cells)	(a)	No

Table 8.3.2.3-2. Functions, performance measures, and performance goals for Issue 2.7 (repository design criteria for radiological safety) (page 7 of 13)

Subfunction	Process or activity	Performance measure		Tentative goal	Needed confidence	Site data?
RADIOLOGICAL PROTECTION (FUNCTION 1) (continued)						
J Provide repository facility ventilation systems that will protect against radiation exposure (continued)	Separate ventilation systems of surface waste-handling areas from other surface areas	Leakage between systems	J4	Very low leakage	(a)	No
		Pressure differential between separate systems	J5	Between 0.1 and 0.5 in. WG	(a)	No
	Separate ventilation systems of underground waste-handling and emplacement areas from mining development areas	Leakage between systems	J6	Very low leakage	(a)	No
		Pressure differential between separate systems	J7	Between 0.1 and 0.5 in. WG	(a)	No
	Provide close-capture ventilation exhaust systems when necessary	System capture efficiency	J8	Adequate capture efficiency	(a)	No
	Filter airstream and exhausts when necessary	Decontamination factor	J9	Adequate decontamination factor	High	Yes
		Number of filter banks	J10	Single stage available for normally clean areas	High	Yes
			J11	Two stage in service for expected contamination areas	(a)	No
	Flow pattern of ventilation should direct potential contamination away from personnel	Flow patterns of ventilation systems	J12	Potential contamination always directed away from personnel and to filterable exhausts	(a)	No

Table 8.3.2.3-2. Functions, performance measures, and performance goals for Issue 2.7 (repository design criteria for radiological safety) (page 8 of 13)

Subfunction	Process or activity	Performance measure	Tentative goal	Needed confidence	Site data?
DESIGN AND PROTECTION OF STRUCTURES, SYSTEMS, AND COMPONENTS IMPORTANT TO SAFETY (FUNCTION 2)					
K Protect structures, systems, and components important to safety against natural phenomena and environmental conditions	House structures, systems, and components important to safety in buildings designed to withstand credible natural phenomena and environmental conditions	Effects of credible natural phenomena and natural conditions on structures, systems, and components important to safety	K1 Structures, systems, and components function as designed to meet radiological dose limits	High	Yes
L Protect structures, systems, and components important to safety against dynamic effects of equipment failure and similar events	House structures, systems, and components important to safety in structures designed to withstand dynamic effects of equipment failures and similar events	Response of structures, systems, and components important to safety to dynamic effects of equipment failure and similar events	L1 Structures, systems, and components function as designed to meet radiological dose limits	(a)	No
M Protect structures, systems, and components important to safety against fires and explosions	House structures, systems, and components important to safety in structures with fire and explosion detection/suppression equipment	Effects of fires, explosions, and suppression systems on structures, systems, and components important to safety	M1 Structures, systems, and components function as designed to meet radiological dose limits	(a)	No

Table 8.3.2.3-2. Functions, performance measures, and performance goals for Issue 2.7 (repository design criteria for radiological safety) (page 9 of 13)

	Subfunction	Process or activity	Performance measure		Tentative goal	Needed confidence	Site data?
	DESIGN AND PROTECTION OF STRUCTURES, SYSTEMS, AND COMPONENTS IMPORTANT TO SAFETY (FUNCTION 2) (continued)						
N	Ensure that structures, systems, and components important to safety will maintain control of radioactive materials, permit prompt termination of operations, and allow evacuation of personnel during emergencies	Design structures, systems, and components important to safety to maintain control of radioactive material during emergencies	Maintenance of control of radioactive material during design-basis accidents	N1	Control of radioactive material maintained such that dose limits are met	(a)	No
		Design structures, systems, and components important to safety to permit prompt shutdown of nonsafety related operations during an emergency	Time to shutdown non-safety related operations during design-basis accidents	N2	Prompt shutdown of non-safety related operations during design-basis accidents	(a)	No
		Design structures, systems, and components important to safety so that they facilitate the evacuation of the repository during emergencies	Effects of structures, systems, and components important to safety on evacuation during an emergency	N3	Minimal effect of structures, systems, and components important to safety on evacuation of personnel	(a)	No
O	Ensure that utilities important to safety will continue their safety function during emergencies	Design utilities important to safety to continue their safety functions during conditions anticipated during an emergency	Ability of utilities important to safety to continue to perform safety functions during design-basis accidents	O1	Utilities important to safety continue to perform safety functions during design-basis accidents	High	Yes

Table 8.3.2.3-2. Functions, performance measures, and performance goals for Issue 2.7 (repository design criteria for radiological safety) (page 10 of 13)

Subfunction	Process or activity	Performance measure	Tentative goal	Needed confidence	Site data?
DESIGN AND PROTECTION OF STRUCTURES, SYSTEMS, AND COMPONENTS IMPORTANT TO SAFETY (FUNCTION 2) (continued)					
P Ensure that structures, systems, and components important to safety will facilitate inspection, testing, and maintenance	Design structures, systems, and components important to safety to facilitate inspection, testing, and maintenance	Complexity of inspection operations for structures, systems, and components important to safety	P1 Inspection of structures, systems, and components important to safety relatively simple	(a)	No
		Complexity of testing operations for structures, systems, and components important to safety	P2 Testing of structures, systems, and components important to safety relatively simple	(a)	No
		Complexity of maintenance operations for structures, systems, and components important to safety	P3 Maintenance of structures, systems, and components important to safety relatively simple	(a)	No
Q Provide timely backup power to structures, systems, and components important to safety when needed and during emergencies	Design power systems with backup power capability (diesel generators or other suitable means)	Capacity of backup power supply	Q1 Sufficient capacity to operate all structures, systems, and components important to safety	(a)	No
		Time for backup power supply to become operable	Q2 Response time adequate to serve structures, systems, and components important to safety	(a)	No
R Provide instrumentation and control systems to monitor and control structures, systems, and components important to safety for all anticipated ranges of operation	Design structures, systems, and components with instrumentation and control systems	Range of operation of monitoring instrumentation	R1 Monitors operable for anticipated ranges of system operation, including design-basis accident conditions	High	Yes
		Range of operation of control instrumentation	R2 Control systems operable for anticipated ranges of system operation, including design-basis accidents	High	Yes

Table 8.3.2.3-2. Functions, performance measures, and performance goals for Issue 2.7 (repository design criteria for radiological safety) (page 11 of 13)

Subfunction	Process or activity	Performance measure		Tentative goal	Needed confidence	Site data?
DESIGN AND PROTECTION OF STRUCTURES, SYSTEMS, AND COMPONENTS IMPORTANT TO SAFETY (FUNCTION 2) (continued)						
R Provide instrumentation and control systems to monitor and control structures, systems, and components important to safety for all anticipated ranges of operation (continued)		Ability to control structures, systems, and components important to safety	R3	Adequate control of essential functions of structures, systems, and components important to safety	High	Yes
CRITICALITY CONTROL (FUNCTION 3)						
S Criticality control	Maintain control of geometry of waste configurations in all phases of waste handling and disposal	Geometry of waste storage arrays	S1	Geometries unfavorable to nuclear criticality	(a)	No
		Geometry of waste package configurations	S2	Geometries unfavorable to nuclear criticality	(a)	No
		Geometry of emplaced waste	S3	Geometries unfavorable to nuclear criticality	(a)	No
		Possibility of accidental disruption of waste geometry leading to unfavorable configurations	S4	Very low probability	High	Yes
	Maintain subcritical assemblies and masses of fissile material in all phases of waste handling and disposal	Mass and fissile content of waste storage arrays	S5	Masses and fissile contents subcritical (see goal S13)	(a)	No
		Mass and fissile content of waste package configurations	S6	Masses and fissile contents subcritical (see goal S13)	(a)	No
		Mass and fissile content of emplaced waste	S7	Masses and fissile contents subcritical (see goal S13)	(a)	No
		Possibility of accidental disruption of waste leading to unfavorable concentrations of fissile materials	S8	Very low probability	High	Yes

Table 8.3.2.3-2. Functions, performance measures, and performance goals for Issue 2.7 (repository design criteria for radiological safety) (page 12 of 13)

Subfunction	Process or activity	Performance measure		Tentative goal	Needed confidence	Site data?
CRITICALITY CONTROL (FUNCTION 3) (continued)						
S Criticality control (continued)	Control the introduction of any neutron moderating materials to waste containing areas	Moderating materials in or around waste storage arrays	S9	No significant moderating materials	(a)	No
		Moderating materials in or around waste package configurations	S10	No significant moderating materials	(a)	No
		Moderating materials in or around emplaced waste	S11	No significant moderating materials	High	Yes
		Possibility of accidental introduction of moderating materials into areas containing waste	S12	Very low probability	High	Yes
	Neutron multiplication	K_{eff} of fissile materials	S13	K_{eff} <0.95 as specified in 10 CFR 60.131(b)(7)	High	Yes
COMPLIANCE WITH MINING REGULATIONS (FUNCTION 4)						
T Comply with mining regulations	Protection of workers who perform assigned safety function	Ability of workers to perform assigned safety functions	T1	Workers perform their assigned safety functions	(a)	No
WASTE TREATMENT (FUNCTION 5)						
U Treat waste	Collect secondary site-generated radioactive waste from waste handling areas	Fraction of site-generated waste collected	U1	Site-generated waste collected	(a)	No

Table 8.3.2.3-2. Functions, performance measures, and performance goals for Issue 2.7 (repository design criteria for radiological safety) (page 13 of 13)

Subfunction	Process or activity	Performance measure	Tentative goal	Needed confidence	Site data?
		WASTE TREATMENT (FUNCTION 5) (continued)			
U Treat waste (continued)	Treat and stabilize or recycle secondary site-generated waste collected	Fraction of site-generated waste treated and stabilized or recycled	U2 Site-generated waste treated and stabilized or recycled	(a)	No
	Package treated and stabilized secondary site-generated waste for disposal offsite	Fraction of treated and stabilized site-generated waste packaged	U3 Treated and stabilized site-generated waste packaged	(a)	No

*Needed confidence for nonsite related data will be provided in the plans for repository design.

Table 8.3.2.3-3. Parameters required for Issue 2.7 (repository design criteria for radiological safety) (page 1 of 6)

Related performance goal[a]	Performance or design parameter	Parameter descriptor	Tentative parameter goal	Needed confidence	Expected parameter value	Current confidence	SCP section providing parameter
A1, D2, G2, J1, J9, J10	Dust and particle size distributions	Underground and at site	1 to 10 micron, normal	High	Data not available	Data not available	(c)
A3	Radon emanation rate from tuff	TSw2 unit[b]	(d)	High	0.48 pCi per square meter per second	Low	8.3.1.15, (c)
C2, I2, S13	Bulk density of host rock	TSw2 unit	(d)	High	2.26 to 2.32 g/cc	Medium	8.3.1.15
C2, I2, S11, S13	Elemental composition of host rock	TSw2 unit	Normal composition for tuffs	High	Normal composition for tuffs	Medium	8.3.1.3
C2, I2, S11, S13	Water content of host rock as a function of temperature and time	TSw2 unit	(d)	High	65% saturation	Medium	8.3.1.2
G4	Wind speeds	80 km radius	(d)	High	See Figures 5-3 to 5-7, and Tables 5-6 and 5-7	Medium	8.3.1.12
G4	Wind direction	80 km radius	(d)	High	See Figures 5-3 to 5-7, and Tables 5-6 and 5-7	Medium	8.3.1.12
G4	Atmospheric stability	80 km radius	(d)	Medium	See Table 5-11	Medium	8.3.1.12
G4	Mixing layer depth	80 km radius	(d)	Medium	(e)	Medium	8.3.1.12

Table 8.3.2.3-3. Parameters required for Issue 2.7 (repository design criteria for radiological safety) (page 2 of 6)

Related performance goal[a]	Performance or design parameter	Parameter descriptor	Tentative parameter goal	Needed confidence	Expected parameter value	Current confidence	SCP section providing parameter
G4	Average ambient temperature	80 km radius	(d)	Medium	See Tables 5-2 and 5-3	Medium	8.3.1.12
G4	Atmospheric moisture	80 km radius	(d)	Medium	See Tables 5-2 and 5-5	Medium	8.3.1.12
G4	Precipitation: type, amount, intensity, etc.	80 km radius	(d)	Medium	See Tables 5-2 and 5-4	Medium	8.3.1.12
G4	Barometric pressure	80 km radius	(d)	Medium	See Table 5-2	Medium	8.3.1.12
G4	Size and distance of topographic features from release points	80 km radius	Topographic features beneficial to dispersion	Medium	See U.S. Geological Survey topographic maps	High	Literature
G4	Bioaccumulation of radionuclides in terrestrial flora	80 km radius	(d)	Medium	1×10^{-28} to 1×10^{-14} Ci/kg[f]	Medium	(c)
G4	Bioaccumulation of radionuclides in terrestrial fauna	80 km radius	(d)	Medium	1×10^{-25} to 1×10^{-15} Ci/kg[g]	Medium	(c)
G4	Types of crops raised	80 km radius	(d)	Medium	(h)	Medium	(c)
G4	Amounts of crops raised	80 km radius	(d)	Medium	1×10^{4} to 1×10^{7} kg/yr[i]	Medium	(c)
G4	Types of crops consumed	80 km radius	(d)	Medium	(j)	Medium	(c)

Table 8.3.2.3-3. Parameters required for Issue 2.7 (repository design criteria for radiological safety) (page 3 of 6)

Related performance goal[a]	Performance or design parameter	Parameter descriptor	Tentative parameter goal	Needed confidence	Expected parameter value	Current confidence	SCP section providing parameter
G4	Amounts of crops consumed	80 km radius	(d)	Medium	1 x 10^4 to 1 x 10^5 kg/yr	Medium	(c)
G4	Types of animals raised	80 km radius	(d)	Medium	(k)	Medium	(c)
G4	Amounts of animals raised	80 km radius	(d)	Medium	1 x 10^1 to 1 x 10^5 kg/yr	Medium	(c)
G4	Types of animals consumed	80 km radius	(d)	Medium	(l)	Medium	(c)
G4	Amounts of animals consumed	80 km radius	(d)	Medium	1 x 10^4 to 1 x 10^6 kg/yr	Medium	(c)
G4	Animal consumption of forage	80 km radius	(d)	Medium	1 x 10^1 to 1 x 10^4 kg/yr	Medium	(c)
G4	Forage storage time	80 km radius	Goal is values given in Reg. guide 1.109 (NRC, 1977a)	Medium	Data not available	Data not available	(c)
G4	Grazing yield and period	80 km radius	(d)	Medium	75 to 100% of the year	High	(c)
G4	Radius of crop and animal area	80 km radius	(d)	Medium	50 km to bulk of cropland and farms (W to SW)	High	(c)

Table 8.3.2.3-3. Parameters required for Issue 2.7 (repository design criteria for radiological safety) (page 4 of 6)

Related performance goal[a]	Performance or design parameter	Parameter descriptor	Tentative parameter goal	Needed confidence	Expected parameter value	Current confidence	SCP section providing parameter
G4	Volumetric flow of surface water to water bodies	80 km radius	Little or no surface run-off	Medium	Environmental assessment, Section 3.3.1 (DOE, 1986b)	Medium	(c)
G4	Recreational uses of water bodies	80 km radius	Very little recreational use of water	Low	(m)	(m)	(c)
J1	Repository design ventilation pressure drop conditions	Underground	See Section 8.3.2.5	High	See Section 8.3.2.5	See Section 8.3.2.5	8.3.2.5
D5, J9, J10, K1, O1, R1, R2, R3, S4, S8, S12	Frequency and magnitudes of						
	- Tornadoes	At facility	(d)	High	See Section 5.1.1.6[n]	Medium	8.3.1.12
	- Cloud-to-ground lightning strikes	At facility	(d)	Medium	About 18 per year, magnitude unknown	Medium	8.3.1.12
	- Sandstorms/windstorms	At facility	(d)	High	See Table 5-8, and Section 5.1.1.6	Medium	8.3.1.12
	- Snowfall/ice storms	At facility	Rare, low magnitude	High	Rare, low magnitude	Medium	8.3.1.12
	- Repository surface flooding	At facility	PMF[o]	High	PMF[o]	Medium	8.3.1.16

Table 8.3.2.3-3. Parameters required for Issue 2.7 (repository design criteria for radiological safety) (page 5 of 6)

Related performance goal[a]	Performance or design parameter	Parameter descriptor	Tentative parameter goal	Needed confidence	Expected parameter value	Current confidence	SCP section providing parameter
	- Surface and subsurface seismic events	In region	(d)	High	(p)	(p)	8.3.1.17
	- Fault movement within the repository	Surface and subsurface	(d)	High	See Section 1.5.2	Medium	8.3.1.17
D5, J9, J10, K1, O1, R1, R2, R3, S4, S8, S12	- Drift roof fall/ collapse/ failure	Underground	(q)	Medium	Data not available	Data not available	8.3.2.4
	- Landslides	At facility	(q)	Medium	Data not available	Data not available	8.3.1.14
	- Volcanic ash fall	At facility	(q)	Medium	Data not available	Data not available	8.3.1.17
	- Nearby brush fires	Near facilities	(q)	Low	Data not available	Data not available	8.3.1.13
	- Aircraft crashes	At facility	(q)	High	1×10^{-5} to 1×10^{-7} per year	Medium	8.3.1.13
	- Criticality events	In surface and subsurface facilities	Criticality events precluded	High	Not credible	High[r]	8.3.5.5
	- Other potential accidents	Natural or site-related	(s)	High	(s)	(s)	PRAM Program[t]

[a]The letters in this column key the performance parameters to the tentative goals in Table 8.3.2.3-2.
[b]TSw2 unit is the nonlilthophysal Topopah Spring unit (repository horizon).

Table 8.3.2.3-3. Parameters required for Issue 2.7 (repository design criteria for radiological safety) (page 6 of 6)

Related performance goal[a]	Performance or design parameter	Parameter descriptor	Tentative parameter goal	Needed confidence	Expected parameter value	Current confidence	SCP section providing parameter

Footnotes (continued)

[c]Collection of these data are part of the environmental program planned activities and is addressed in the Radiological Monitoring Plan discussed in Section 8.3.1.13 (offsite installations).
[d]Tentative goal is to have further measurements of this parameter verify the range of expected values listed here.
[e]See Quiring (1968).
[f]This range covers all flora for which data is now available, specific values are flora and radionuclide specific.
[g]This range covers all fauna for which data is now available, specific values are fauna and radionuclide specific.
[h]Crops include wheat/grains, corn, apples, potatoes, alfalfa, alfalfa seed, hay, silage, peppers, melons, berries, pecans, leafy vegetables, and honey.
[i]Specific values depend on available crops, crop areas, and crop densities.
[j]Includes all crops listed in footnote h except alfalfa, hay, and silage.
[k]Includes beef cattle, dairy cattle, goats, hogs, sheep, and poultry.
[l]Includes quail, freshwater fish, duck, geese, rabbit, and deer, plus those listed in footnote k.
[m]Very limited use of Crystal Reservoir; swimming pool data not yet available.
[n]Probability at Yucca Mountain is approximately 7.5×10^{-4} in any given year; magnitude is F-0 on Fujita tornado scale (very weak).
[o]PMF = probable maximum flood; the PMF is still under investigation.
[p]Information on seismic events may be found in Section 8.3.1.17.
[q]Parameter goal to be evaluated in terms of frequency and consequence.
[r]Design will preclude criticality accidents per 10 CFR 60.131(b)(7).
[s]Other accident-specific goals to be evaluated as appropriate under preclosure risk assessment methodology (PRAM).
[t]PRAM = preclosure risk assessment methodology.

8.3.2.4 Performance Allocation Tables for Nonradiological Health and Safety

These allocation tables address the nonradiological requirements for health and safety of workers. The NRC specifies that DOE should comply with mining regulations (10 CFR 60.131(b)(9)). The NRC points out that the design of the geologic repository operations area should include provisions for worker protection adequate to ensure that structures, systems, and components ITS can perform their intended functions. Resolution of this issue requires that designs and operating procedures that ensure worker nonradiological health and safety during the preclosure period be selected and implemented.

The Yucca Mountain MGDS elements and subelements that have an impact on the nonradiological health and safety of the work force and visitors include System Elements 1.2.1 (mining), 1.2.2 (waste handling), 1.2.4 (decommissioning), and 1.2.5 (support). The performance allocation for this issue is presented only for those systems elements or subelements that require site-specific data for design and development of operational procedures to ensure workers nonradiological health and safety. The system subelements that require site-specific data for design and the development of operational procedures to ensure worker nonradiological health and safety are the following:

System subelement	Subject
1.2.1.1	Access construction
1.2.1.2	Drift construction
1.2.1.3	Borehole construction
1.2.1.6	Mining ventilation
1.2.2.5	Retrieval
1.2.2.7	Waste ventilation
1.2.4.1	Underground closure
1.2.5.6	Maintenance
1.2.5.9.2	Nonradiological monitoring

The functions, processes performed, performance measures, performance goals, and needed confidence for achieving the stated performance goals for each system element identified are given in Tables 8.3.2.4-1 through 8.3.2.4-9. Those elements selected that do not require site data as input to determine that worker health and safety are achieved are not included.

Table 8.3.2.4-1. Performance measures, goals, and needed confidences for System Element 1.2.1.1 (access construction) pertinent to Issue 4.2, nonradiological health and safety (page 1 of 4)

Function/process	Performance measure	Tentative goal[a]	Needed confidence
Underground facility access and egress	Safe access to underground facilities (usable access for 100 yr)	Limit rock damage	
		- Overbreak <6 in. average	Medium
		- Blast-induced fracture extent into intact rock <3 m average	Medium
	Access closure (combined performance of rock and opening support)	Access closure	
		- Closure rate <1 mm/yr in shafts and ramps	Medium
		- Total closure in ramps <6 in. in 100 yr	Medium
		- Total closure in shafts <3 in. in 100 yr	Medium
		Rockfall	
		- <5 ton average/1,000 ft/yr (ramps)	Medium
		- Maximum rock or slab size <2 tons	Medium
		- Rockfall in ramps contained by support system	Medium
		- Rockfall or average liner spall <1/2 ton/1,000 ft/yr (shafts)	Medium

Table 8.3.2.4-1. Performance measures, goals, and needed confidences for System Element 1.2.1.1 (access construction) pertinent to Issue 4.2, nonradiological health and safety (page 2 of 4)

Function/process	Performance measure	Tentative goal[a]	Needed confidence
Underground facility access and egress (continued)		- All rockfall or liner spall to be retained (by supplemental support or liner system) (shafts)	Medium
	Acceptable maintenance frequencies	Maintenance	
		- Inspection and minor maintenance will be done on a continuing basis	Medium
		- Major maintenance frequency >25 yr	Medium
	Access sizes and grades compatible with requirements for personnel, material transport, and utility routing	Grades	
		- Waste ramp grade <10%	High
		- Tuff ramp grade <20%	High
		Size	
		- Men and materials shaft 20 ft minimum diameter	Medium
		- Waste transport ramp roadway width 5 ft greater than waste transporter (minimum clearance between and ramp or ramp equipment equipment >2 ft)	Medium

Table 8.3.2.4-1. Performance measures, goals, and needed confidences for System Element 1.2.1.1 (access construction) pertinent to Issue 4.2, nonradiological health and safety (page 3 of 4)

Function/process	Performance measure	Tentative goal[a]	Needed confidence
Underground facility access and egress (continued)		- Tuff ramp diameter adequate for tuff conveyor movement of major construction equipment and utilities (20 ft)	Medium
Removal of broken rock	Compliance with 30 CFR Part 57	Adequate clearance for rock removal equipment	Medium
		Safety systems (conveyors)	High
		- Barriers and guards	
		- Heat sensors	
		- Slack sensors	
		- Back run preventers	
		Dust suppression	High
Ventilation supply and exhaust	Pressure drops in accesses	Accesses sized to limit air velocities and to accommodate future changes in air demands	
		- <3,000 ft/min in shafts	Medium
		- <1,500 ft/min in ramps	Medium
		- >60 ft/min in all accesses	Medium

Table 8.3.2.4-1. Performance measures, goals, and needed confidences for System Element 1.2.1.1 (access construction) pertinent to Issue 4.2, nonradiological health and safety (page 4 of 4)

Function/process	Performance measure	Tentative goal[a]	Needed confidence
Emergency egress	Compliance with 30 CFR Part 57	Accesses designed to provide safe egress during emergencies	High

[a]These goals are integrated with goals from other issues in the discussion of Issue 4.4, preclosure design and technical feasibility (Section 8.3.2.5, Tables 8.3.2.5-1 through 12). Site characterization-related design or performance parameters, their goals, and confidences are also established in these tables.

Table 8.3.2.4-2. Performance measures, goals, and needed confidences for System Element 1.2.1.2 (drift construction) pertinent to Issue 4.2, nonradiological health and safety (page 1 of 3)

Function/process	Performance measure	Tentative goal[a]	Needed confidence
Underground facility access	Safe and usable access for 100 yr	Limit rock damage	
		- Overbreak <6 in. average	Medium
		- Blast induced fracture extent into intact rock <3 m average	Medium
	Drift closure (combined performance of rock and opening support system)	Drift closure	Medium
		- Rate of closure <1 mm/yr in main and access drifts	Medium
		- Rate of closure <3 mm/yr in waste emplacement drifts	Medium
		- Total closure <6 in. in 100 yr	Medium
	Rockfall quantity and retention	Rockfall retention	Medium
		- <5 ton/1,000 ft/yr	
		- Maximum rock or slab size <2 tons	
		- Rockfall retained by support system	Medium
	Acceptable maintenance frequencies	Maintenance	
		- Inspection and minor maintenance will be performed on a continuing basis	Medium

Table 8.3.2.4-2. Performance measures, goals, and needed confidences for System Element 1.2.1.2 (drift construction) pertinent to Issue 4.2, nonradiological health and safety (page 2 of 3)

Function/process	Performance measure	Tentative goal[a]	Needed confidence
Underground facility access (continued)		- Major maintenance frequencies >25 yr	Medium
	Drift size and grades for personnel and material transport and utility routing	Drift size 6 ft wider than equipment size	High
		Drift grades <8%	High
Removal of broken rock	Compliance with 30 CFR Part 57	Adequate clearance	High
		Safety systems (conveyors)	High
		- Barriers and guards	
		- Heat sensors	
		- Slack sensors	
		Dust control and suppression	High
Ventilation supply and exhaust	Pressure drop in drifts	Drifts adequately sized to limit air velocities and to cover changes in future air needs	
		- Velocities in supply mains 2,000 ft/min	Medium
		- Velocities in returns <2,000 ft/min	Medium
		- >60 ft/min in all occupied drifts	High

Table 8.3.2.4-2. Performance measures, goals, and needed confidences for System Element 1.2.1.2 (drift construction) pertinent to Issue 4.2, nonradiological health and safety (page 3 of 3)

Function/process	Performance measure	Tentative goal[a]	Needed confidence
Emergency egress	Compliance with 30 CFR Part 57	Ventilated emergency escapeways	High

[a]These goals are integrated with goals from other issues in the discussion of Issue 4.4, preclosure design and technical feasibility (Section 8.3.2.5, Tables 8.3.2.5-1 through 12). Site characterization-related design or performance parameters, their goals, and confidences are also established in these tables.

Table 8.3.2.4-3. Performance measures, goals, and needed confidences for System Element 1.2.1.3 (borehole construction) pertinent to Issue 4.2, nonradiological health and safety

Function/process	Performance measure	Tentative goal[a]	Needed confidence
Construct borehole	Compliance with 30 CFR Part 57 and ACGIH[b] (1986)	Air quality requirements same as specified for System Element 1.2.1.6 (mining ventilation)	High

[a]These goals are integrated with goals from other issues in the discussion of Issue 4.4, preclosure design and technical feasibility (Section 8.3.2.5, Tables 8.3.2.5-1 through 12). Site characterization-related design or performance parameters, their goals, and confidences are also established in these tables.

[b]ACGIH = American Conference of Governmental Industrial Hygienists.

Table 8.3.2.4-4. Performance measures, goals, and needed confidences for System Element 1.2.1.6 (mining ventilation) pertinent to Issue 4.2, nonradiological health and safety

Function/process	Performance measure	Tentative goal[a]	Needed confidence
Provide adequate quantity of air to all work areas	Air quality, compliance with 30 CFR Part 57	125 CFM/horsepower of diesel equipment used for mining and mining support	High
		210 CFM/underground worker	High
		Minimum air velocity of 60 ft/min in all active work areas	High
Provide quality air to all work areas	Air quality, compliance with 30 CFR Part 57 and Threshold Limit Values (TLVs) and bioindices specified in ACGIH[b] (1986)	SiO_2 <0.1 mg/m^3	High
		O_2 concentration >19.5 vol%	
		CO <50 ppm time weighted average (TWA); short term exposure limit (STEL) <400 ppm	High
		Radon daughter concentration <1.0 working level (WL) in active work areas	High
		Personnel exposure to radon <4 working level months (WLM) annually	High
		Air cooling power >300 watts/m^2 at 45°C (dry bulb)	High

[a]These goals are integrated with goals from other issues in the discussion of Issue 4.4, preclosure design and technical feasibility (Section 8.3.2.5, Tables 8.3.2.5-1 through 12). Site characterization-related design or performance parameters, their goals, and confidences are also established in these tables.

[b]ACGIH = American Conference of Governmental Industrial Hygienists.

Table 8.3.2.4-5. Performance measures, goals, and needed confidences for System Element 1.2.2.5 (retrieval) pertinent to Issue 4.2, nonradiological health and safety (page 1 of 2)

Function/process	Performance measure	Tentative goal[a]	Needed confidence
Provide access to emplacement borehole	Temperature in retrieval area	Surface rock temperature in shafts and ramps <35°C	High
		Temperature in access drifts <50°C (SRT)[b]	High
		Air temperature during retrieval <40°C	High
	Rock movement	Rock/support movement in accesses <1 mm/yr	Medium
		Rock movement in access drifts <1 mm/yr	Medium
		Rock movement in emplacement drifts <3 mm/yr	Medium
		Total closure in shafts <3 in. in 100 yr	Medium
		Total closure in ramps and drifts <6 in. in 100 yr	Medium
		Rockfall in ramps and drifts <5 ton/1,000 ft/yr	Medium
		Maximum rock or slab size <2 ton	Medium
		Rockfall in shaft <1/2 ton/1,000 ft/yr	Medium
		All rockfall (accesses and drifts) to be retained by support system (rock size >2 in. diameter)	High

Table 8.3.2.4-5. Performance measures, goals, and needed confidences for System Element 1.2.2.5 (retrieval) pertinent to Issue 4.2, nonradiological health and safety (page 2 of 2)

Function/process	Performance measure	Tentative goal[a]	Needed confidence
Provide access to emplacement boreholes	Maintenance	Inspection and minor maintenance will be done on a continuing basis	Medium
		Major maintenance frequency >25 yr	Medium

[a]These goals are integrated with goals from other issues in the discussion of Issue 4.4, preclosure design and technical feasibility (Section 8.3.2.5, Tables 8.3.2.5-1 through 12). Site characterization-related design or performance parameters, their goals, and confidences are also established in these tables.

[b]SRT = Standard room temperature.

Table 8.3.2.4-6. Performance measures, goals, and needed confidences for System Element 1.2.2.7 (waste ventilation) pertinent to Issue 4.2, nonradiological health and safety

Function/process	Performance measure	Tentative goal[a]	Needed confidence
Functions/processes and goals for waste ventilation are the same as those specified for System Element 1.2.1.6 (mining ventilation) except for the requirements for air cooling power and drift cooldown, which are specified below.			
Air quality	Air cooling power	Air cooling power required for inspection or light maintenance in waste emplacement area to be 300 watts/m^2 at 45°C (dry bulb) Air cooling power required for heavy maintenance or retrieval (emplacement drifts) to be 500 watts/m^2 at 40°C (dry bulb)	
Cooldown of rock for reentry of emplacement drifts to perform heavy maintenance or retrieval	Rock surface temperature	Surface rock temperature <50°C	

[a]These goals are integrated with goals from other issues in the discussion of Issue 4.4, preclosure design and technical feasibility (Section 8.3.2.5, Tables 8.3.2.5-1 through 12). Site characterization-related design or performance parameters, their goals, and confidences are also established in these tables.

Table 8.3.2.4-7. Performance measures, goals, and needed confidences for System Element 1.2.4.1 (underground closure) pertinent to Issue 4.2, nonradiological health and safety

Function/process	Performance measure	Tentative goal[a]	Needed confidence
Backfill of drifts and installation of postclosure seals	Temperature	Air cooling power >500 watts/m^2 at 40°C (dry bulb)	High
		Rock surface temperature <50°C	Medium
		Air temperature <40°C	High
	Compliance with 30 CFR Part 57 and ACGIH[b] (1986)	SiO_2 concentration <0.1 mg/m^3	High
		O_2 concentration >19.5 vol%	
		CO <50 ppm time weighted average (TWA); short term exposure limit (STEL) <400 ppm	High
		Radon daughter concentration <1.0 working level month (WLM) in active work areas	High
		Personnel exposure to radon <4 working level months (WLM) annually	High

[a]These goals are integrated with goals from other issues in the discussion of Issue 4.4, preclosure design and technical feasibility (Section 8.3.2.5, Tables 8.3.2.5-1 through 12). Site characterization-related design or performance parameters, their goals, and confidences are also established in these tables.

[b]ACGIH = American Conference of Governmental Industrial Hygienists.

Table 8.3.2.4-8. Performance measures, goals, and needed confidences for System Element 1.2.5.6 (maintenance) pertinent to Issue 4.2, nonradiological health and safety

Function/process	Performance measure	Tentative goal[a]	Needed confidence
Access (shaft and ramps) maintenance	Closure and rockfall	Rock movement	
		- <1 mm/yr	Medium
		- <3 in. total in shaft (100 yr)	Medium
		Rockfall	
		- <5 ton/1,000 ft/yr (ramp)	Medium
		- Maximum rock or slab size <2 tons	Medium
		- <1/2 ton/1,000 ft/yr (shaft)	Medium
		All rockfall >2 in. diameter retained by support system	Medium
Drift maintenance	Usability for 100 yr	Inspection and maintenance will be done on a continuing basis	Medium
		Major maintenance frequency >25 yr	Medium

[a]These goals are integrated with goals from other issues in the discussion of Issue 4.4, preclosure design and technical feasibility (Section 8.3.2.5, Tables 8.3.2.5-1 through 12). Site characterization-related design or performance parameters, their goals, and confidences are also established in these tables.

Table 8.3.2.4-9. Performance measures, goals, and needed confidences for System Element 1.2.5.9.2 (nonradiological monitoring) pertinent to Issue 4.2, nonradiological health and safety

Function/process	Performance measure	Tentative goal[a]	Needed confidence
Monitor usability of shafts, ramps, and drifts during construction, operation, retrieval, closure, and decommissioning	Items important to operational safety monitored and displayed in repository control center	Continuous monitoring of - Temperature - Rock movement - Rock support system (visual) - Air quality - Water inflow - Seismic activity	High

[a]These goals are integrated with goals from other issues in the discussion of Issue 4.4, preclosure design and technical feasibility (Section 8.3.2.5, Tables 8.3.2.5-1 through 12). Site characterization-related design or performance parameters, their goals, and confidences are also established in these tables.

8.3.2.5 Performance Allocation Tables for Preclosure Design and Technical Feasibility

Regulatory basis for the issue

Issue 4.4 (preclosure design and technical feasibility) questions whether the repository can be designed, constructed, operated, and closed using reasonably available or proven technology or if it will be necessary to extrapolate beyond current technologies in order to perform the functions identified by this issue. The regulatory basis for addressing this issue and the subsidiary information needs is contained in 10 CFR 60.133 and 10 CFR Part 960.

System elements

The Yucca Mountain MGDS elements that were selected as pertinent to this issue are given in the following list. The elements that will be evaluated before the conclusion can be made that the repository can be constructed, operated, closed, and decommissioned using currently available technology are as follows:

System element	Name
1.1	Site
1.1.1	Surface
1.1.2	Subsurface
1.2	Repository
1.2.1	Mining
1.2.1.1	Access construction
1.2.1.2	Drift construction
1.2.1.3	Borehole construction
1.2.1.4	Rock handling
1.2.1.5	Water removal
1.2.1.6	Mining ventilation
1.2.2	Waste Handling
1.2.2.1	Receiving
1.2.2.2	Preparation
1.2.2.3	Storage
1.2.2.4	Emplacement
1.2.2.5	Retrieval
1.2.2.6	Shipping
1.2.2.7	Waste handling ventilation
1.2.2.8	Contamination control
1.2.4	Decommissioning
1.2.4.1	Underground closure
1.2.4.2	Surface facility decommissioning

The functions or processes for each of these elements are given in Tables 8.3.2.5-1 through 8.3.2.5-12. These tables also include the performance measures used to evaluate performance in each element, the tentative performance goals, the needed confidences, and the performance or design parameters required to evaluate the technology requirements. Tentative goals, current confidences, needed confidences, and expected values are also provided for each performance or design parameter.

Table 8.3.2.5-1. Preliminary performance allocation for System Element 1.1.1, surface (page 1 of 6)

Function or process	Performance measure	Tentative goal	Needed confidence	Performance or design parameter	Tentative goal[a]	Needed confidence	Current confidence	Expected value
Provide sufficient area for surface facilities	Space to accommodate surface facilities (with contingency)	>100 acres for central surface facility	High	Surface topography at facility locations	Topographic maps with 1 m contours	Medium	Medium	1 m contours
		>50 acres for mined material storage	High	Surface topography at candidate mined material storage area	Topographic maps with 2 m contours	Medium	Medium	2 m contours
		>10 acres for each underground access location	Medium	Topography at underground access locations	Topographic maps with 1 m contours	Medium	Medium	1 m contours
		Minimum cut and fill	Medium	Topograpy of surface facility sites	Topographic maps with 1 m contours	Medium	Medium	1 m contours
Provide usable access for waste delivery vehicles	Grades for rail and truck delivery	<6% road grades <2% road grades	High	Surface topography on access routes	Topographic maps with 2 m contours	Medium	Medium	1 m contours
Provide facility sites (including underground accesses) that are not jeopardized by natural or manmade phenomena	Location relative to floodplain	Above floodplain	High	Topography at facility locations	Topographic maps with 1 m contours	High	Medium	1 m contours
				Surface hydrology for 10, 25, 50, 100, 500, yr flood and probable maximum flood (PMF)				
				Area of inundation	Inundation maps with elevation of inundation area to within ±2 m	High	Low	Area map with elevation of inundated area within ±2 m
					Secondary quantities used to derive area of inundation			
					Topography of drainage area 2 m contours	Medium	Medium	2 m contours
					Debris quantity and category	Low	Low	Cannot be estimated with currently available data
	Locations for surface facilities	Facilities important to safety (FITS) not located over potentially active geological structures	High	Identification of any fault within 100 m of FITS with greater than 1 chance in 100 of producing more than 5 cm of surface displacement in 100 yr	Determine existence	High	Low	No such faults are expected to be found

Table 8.3.2.5-1. Preliminary performance allocation for System Element 1.1.1, surface (page 2 of 6)

Function or process	Performance measure	Tentative goal	Needed confidence	Performance or design parameter	Tentative goal[a]	Needed confidence	Current confidence	Expected value
Provide facility sites (including underground accesses) that are not jeopardized by natural or manmade phenomena (continued)				If determined to exist, establish				
				Location at surface	Actual location to accuracy of ±5 m	High	Low	Location within 5 m
				Orientation at surface	Actual orientation to accuracy of ±10°	High	Low	Orientation to 10°
				Probability of exceeding 5 cm displacement under FITS	Probability of 5 cm displacement under FITS <.01 in 100 yr	High	Low	Probability <.01 in 100 yr
		Acceptable potential for vibratory ground motion	High	Design basis ground motion time histories and corresponding response spectra	Time histories and response spectra representative for exceptional earthquakes on nearby faults and underground nuclear explosions (for frequencies between 0.5 and 33 Hz)	Medium to high	Low	0.4-0.6g peak acceleration
				Potential for exceeding design basis ground motion at FITS	<0.1 probability in 100 yr	Medium to high	Low to medium	Probability <0.1 in 100 yr
				Probability vs. peak ground acceleration, peak ground velocity, and peak velocity response at selected frequencies at surface FITS locations	Values estimated for annual probability ranging from 10^{-2} to 10^{-6} per yr	Medium to high	Low	Cannot be estimated based on current data
		Acceptable potential for volcanic eruption at surface facilities	High	Probability of volcanic eruption that would disrupt surface facilities	Probability <.0001 in 100 yr	High	Medium to high	Probability <.0001 in 100 yr
		Design basis ash fall thickness at surface facility locations (including shaft and ramp portals)	Medium	Design basis ash fall thickness	<0.1 probability of exceeding design basis ash fall in 100 yr	Low to medium	Low	Probability <0.1 in 100 yr

Table 8.3.2.5-1. Preliminary performance allocation for System Element 1.1.1, surface (page 3 of 6)

Function or process	Performance measure	Tentative goal	Needed confidence	Performance or design parameter	Tentative goal[a]	Needed confidence	Current confidence	Expected value
Provide facility sites (including underground accesses) that have acceptable soil and rock conditions	Soil and rock conditions	Stable foundations on soil and rock under static load conditions	Medium	Allowable foundation bearing load pressure for soil considering shear failure and settlement (total and differential)	Allowable bearing pressure >0.2 MPa	Medium	Low to medium	0.2-0.4 MPa
				Allowable foundation bearing load pressure for rock considering shear failure and settlement (total and differential)	Allowable bearing pressure >14 MPa	Medium	Low to medium	21 MPa
		Stable retaining walls on soil and rock under static load conditions	Medium	Active and passive soil pressures for flexible and rigid structural walls	Earth pressure coefficient active >0.25 passive >3.4	Medium	Low	 0.27 3.70
				Active and passive rock pressure for flexible and rigid structural walls	Earth pressure coefficient active >0.25 passive >3.4	Medium	Low	 0.27 3.70
		Stable slopes for static and dynamic loading conditions	Medium to high	Factor of safety for an identified mechanism of potential slope failure in soil for static and dynamic loading conditions	For slopes potentially impacting FITS F.S.[b] >1.5 (static) F.S. >1.2 (dynamic)	High	Low	Cannot be estimated based on current data
					For slopes potentially impacting other structures F.S. >1.3 (static)	Medium	Low	Cannot be estimated based on current data
				Factor of safety for an identified mechanism of potential slope failure in rock for static and dynamic loading conditions	For slopes potentially impacting FITS F.S. >1.5 (static) F.S. >1.2 (dynamic)	High	Low	Cannot be estimated based on current data

Table 8.3.2.5-1. Preliminary performance allocation for System Element 1.1.1, surface (page 4 of 6)

Function or process	Performance measure	Tentative goal	Needed confidence	Performance or design parameter	Tentative goal[a]	Needed confidence	Current confidence	Expected value
Provide facility sites (including underground accesses) that have acceptable soil and rock conditions (continued)					For slopes potentially impacting other structures F.S. >1.3 (static)	Medium	Low	Cannot be estimated based on current data
		Suitable hydraulic related soil conditions considering infiltration/ runoff characteristics and erosion potential	Medium	Favorable infiltration: runoff ratio	See Section 8.3.1.2 (geohydrology)	High	Low	See 8.3.1.2
				Favorable hydraulic induced soil erosion characteristics	Scour around bridge piers <13 m in 100 yr	Medium	Low	See 8.3.1.6
					Bed erosion <5 m in 100 yr	Medium	Low	Cannot be estimated based on current data
					Sheet erosion <1 m in 100 yr	Medium	Low	Cannot be estimated based on current data
		Stable foundations on soil and rock for dynamic loading conditions (for FITS)	High	Favorable soil-structure interaction considering displacements and degree of yielding in soil beneath base of building[c]	Total displacement <3 in.	High	Low	Cannot be estimated based on current data
					Percentage of soil that has yielded beneath base of building <10%	High	Low	Cannot be estimated based on current data
				Favorable rock-structure interaction considering displacements and degree of yielding in soil beneath base of building[c]	Total displacement <3 in.	High	Low	Cannot be estimated based on current data
					Percentage of rock that has yielded beneath base of building <10%	High	Low	Cannot be estimated based on current data
		Stable retaining walls on soil and rock under dynamic loading conditions (for FITS)	High	Favorable soil-structure interaction considering displacements and degree of yielding in soil beneath base of building	Total displacement <6 in.	High	Low	Cannot be estimated based on current data
					Percentage of soil that has yielded beneath base of building <10%	High	Low	Cannot be estimated based on current data

Table 8.3.2.5-1. Preliminary performance allocation for System Element 1.1.1, surface (page 5 of 6)

Function or process	Performance measure	Tentative goal	Needed confidence	Performance or design parameter	Tentative goal[a]	Needed confidence	Current confidence	Expected value
Provide facility sites (including underground accesses) that have acceptable soil and rock conditions (continued)				Favorable rock-structure interaction considering displacements and degree of yielding in soil beneath base of building	Total displacement <2 in.	High	Low	Cannot be estimated based on current data
					Percentage of rock that has yielded beneath base of building <10%	High	Low	Cannot be estimated based on current data
		Soils not subject excessive volume change	Medium	Magnitude and rate of time dependent settlement in soils below earthfills[d]	Total settlement <4 in.	Medium	Low	Settlement <4 in.
				Magnitude of swell in subgrade soils below roads[d]	Total swell <1 in.	Medium	Low	Swell <1 in.
				Magnitude of soil collapse below surface facilities (foundations, earthfills, and roads) due to saturation and/or loading[d]	Total collapse <2%	Medium	Low	Cannot be estimated based on current data
					In situ density >90% of maximum dry density	Medium	Low to medium	Cannot be estimated based on current data
				Favorable soil liquifaction potential for saturated low density soils under dynamic loading conditions[d]	In situ density >85% of maximum dry density	Medium	Low to medium	Density >93.5%
					Well graded soil	Medium	Low to medium	Poorly graded gravel or silty gravel
Protection and confinement of operational activities	Facilities adequate to withstand natural weather phenomena without damage to functional capability	Facilities not damaged by weather extremes	High	Design wind load at surface facility locations (normal winds)	80 mph	Medium	Medium	80 mph
				Design basis tornado				
				Probability of occurrence	$<1 \times 10^{-7}$ per yr	Medium	Low	$<1 \times 10^{-7}$ per yr
				Maximum wind speed	180 mph (combined translational and rotational velocity)	High	Medium	<180 mph
				Maximum atmospheric pressure drop	0.7 psi	High	Low	0.7 psi

Table 8.3.2.5-1. Preliminary performance allocation for System Element 1.1.1, surface (page 6 of 6)

Function or process	Performance measure	Tentative goal	Needed confidence	Performance or design parameter	Tentative goal[a]	Needed confidence	Current confidence	Expected value
Protection and confinement and operational activities (continued)				Design snow load at surface facility locations	10-16 in.	High	Medium	14 in.
				Design precipitation rate at surface facilities	2-4 in./h	High	Medium	3 in./h
Provide proper environment for personnel and equipment	Proper environment for personnel and equipment under normal weather extremes	Heating and cooling design values	High	Heating and air conditioning design values	No site characterization data is required. Existing data from near vicinity locations is adequate if normalized to Yucca Mountain sites. Values will be developed and presented in the repository design plan.			
		Site location	Medium	Site locations	Coordinates of facility locations	Medium	High	Coordinates within ±5 m
		Site elevation	Medium	Site elevation	Elevations of surface facilities	Medium	High	Elevations within ±5 m

[a]Tentative goals, including ranges, for performance or design parameters are based on current reference values used to repository conceptual design and supporting analyses (Tables 6-11 through 6-16), and limited sensitivity analyses reported in Appendix I of the Site Characterization Plan-Concenptual Design Report (SNL, 1987) and its references and in Ehgartner (1987).

[b]F.S. = factor of safety.

[c]If the alluvium or rock adjacent to the foundation has shear velocities greater than 3,500 ft/s, then a soil-structure interaction analysis will probably not be necessary.

[d]The need for these design and performance parameters or characterization parameters is contingent on the soil and rock conditions encountered. On the basis of the preliminary soil and rock data from the site, these parameters are not currently required.

Table 8.3.2.5-2. Preliminary performance allocation for System Element 1.1.2, subsurface (page 1 of 5)

Function or process	Performance measure	Tentative goal	Needed confidence	Performance or design parameter	Tentative goal[a]	Needed confidence	Current confidence	Expected value[b]
Provide adequate area for distributing waste (with contingency) and required overburden	Area for 70,000 metric tons of waste and overburden >200 m	Goal for needed area established in Issue 1.11 (see Section 8.3.2.2 for needed site parameters)	High		See Issue 1.11, Section 8.3.2.2			
Provide underground sites (including accesses) that are not jeopardized by natural or manmade phenomena	Ability to continue preclosure operations and retrieve waste	Underground facilities not located in areas with a high probability of disruption by faulting	High	Identification and characterization of significant Quaternary faults in the repository block	Determine existence	High	Low	No such faults are expected to be found in repository, but two such faults bound block
				If determined to exist, establish				
				Location at repository level projected from surface data	Actual location to accuracy of ±20 m	High	Low	Cannot be estimated based on current data
				Orientation (strike and dip)	Actual orientation to accuracy of ±10°	High	Low	Cannot be estimated based on current data
				Probability of exceeding 7 cm displacement in areas of waste emplacement	Probability of 7 cm displacement in waste emplacement area <1 chance in 10 in 100 yr	Medium	Low	Probability <0.1 in 100 yr
		Acceptable potential for vibratory ground motion	High	Design basis ground motion time histories, and corresponding spectra at underground facility	Time histories and response spectra representative of 10,000-yr cummulative-slip earthquakes on nearby faults and underground nuclear explosions (for frequencies between 0.5 and 33 Hz)	Medium to high	Low	0.2-0.3g peak acceleration (subsurface)
			High	Combined potential for vibratory ground motion at underground facility locations	<1 chance in 10 of exceeding design basis ground motion in 100 yr	Medium to high	Medium to low	Probability <0.1 in 100 yr

Table 8.3.2.5-2. Preliminary performance allocation for System Element 1.1.2, subsurface (page 2 of 5)

Function or process	Performance measure	Tentative goal	Needed confidence	Performance or design parameter	Tentative goal[a]	Needed confidence	Current confidence	Expected value[b]
Provide adequate area for distributing waste (with contingency) and required overburden (continued)		Acceptable potential for volcanic eruption through underground facility	High	Probability of volcanic eruption through area of waste emplacement	Probability $<1 \times 10^{-6}$ per yr	High	Low	Probability $<1 \times 10^{-6}$
Provide host rock thickness for drift construction and waste emplacement	Thickness for drift construction and waste emplacement	Host rock thickness >50 m	High	Stratigraphic contacts for top and and bottom of the TSw2 formation within candidate areas for repository	Determine elevation of stratigraphic contacts at selected points within candidate repository area to accuracy of ±10 m (Note: goal is to determine potential usable extent of acceptable area based on this and other criteria)	High	Low	Thickness of TSw2 within area meeting other selected guidelines for repository horizon defined in Issue 1.11 (Section 8.3.2.2)
Provide physical properties adequate for construction and operation of stable (safe) underground accesses, drifts, emplacement boreholes, and support facilities for normal and credible abnormal conditions	Usable openings of required sites	Accessways and drifts usable for 100 yr	High	Rock properties in primary area Poisson's ratio (intact rock)	TSw1 0.20-0.30 (NL)[c]	Low	Low to medium	0.20-0.30
					0.13-0.19 (L)[d]	Low	Low	0.13-0.19
					TSw2 0.19-0.29	Medium	Medium	0.19-0.29
				In situ stress (rock mass)	Vertical 6.3-7.7 MPa (average) value for 300 m)	Medium	Low to medium	6.3-7.7
					Minimum horizontal stress ratio 0.3-0.8	Medium	Low	0.3-0.8
					Maximum horizontal stress ratio 0.3-1.0	Medium	Low	0.3-1.0
					Bearing of minimum horizontal stress between N 50 E-N 65 E	Medium	Medium	N 50° W-N 65° W
					Bearing of maximum horizontal stress between N 25 E-N 40 E	Medium	Medium	N 25° E-N 40° E
				Initial temperature (rock mass)	TSw2 23-25°C	Medium	Medium	23-25°C
				Coefficient of thermal expansion (rock mass)	TSw1 current mean ±15% (NL and L)	Medium	Low to medium	12 x 10 $^{-6}$/K
					TSw2 current mean ±15%	Medium	Medium	9 x 10 $^{-6}$/K

Table 8.3.2.5-7. Preliminary performance allocation for System Element 1.1.2, subsurface (page 3 of 5)

Function or process	Performance measure	Tentative goal	Needed confidence	Performance or design parameter	Tentative goal[a]	Needed confidence	Current confidence	Expected value[b]
Provide physical properties adequate for construction and operation of stable (safe) underground accesses, drifts, emplacement boreholes, and support facilities for normal and credible abnormal conditions (continued)				Thermal conductivity (rock mass)	TSw1 current mean ±20% (NL) (Dry)	Medium	Low to medium	1.2 W/m-K
					TSw1 current mean ±20% (L) (Dry)	Medium	Low	0.8 W/m-K
					TSw2 current mean ±20% (Dry)	Medium	Low to medium	1.4 W/m-K
				Young's modulus (intact rock)	TSw1 12-54 GPa (NL)	Medium	Medium	19-44 GPa
					14-17 GPa (L)	Medium	Low	15.5 GPa
					TSw2 29-33 GPa	Medium	Medium	31 GPa
				Deformation modulus (rock mass)	TSw1 12-20 GPa (NL)	Medium	Low	12-20 GPa
					4-11 GPa (L)	Medium	Medium	4-11 GPa
					TSw2 11-19 GPa	Medium	Low	11-19 GPa
				Heat capacity	TSw1 current mean ±10% (NL) (saturated)	Medium	Low to medium	2.1 J/m³-K
					current mean ±10% (NL) (dry)	Medium	Low to medium	2.0 J/m³-K
					current mean ±10% (L) (saturated)	Medium	Low to medium	1.9 J/m³-K
					current mean ±10% (L) (dry)	Medium	Low to medium	1.4 J/m³-K
					TSw2 current mean ±10% (saturated) (dry)	Medium	Low to medium	2.2 J/m³-K
				Unconfined compressive strength (intact rock)	TCw current mean ±20%		(see footnote e)	
					PTn current mean ±20%		(see footnote e)	
					TSw1 54-207 MPa (NL)	Medium	Medium	67-172 MPa
					13-19 MPa (L)	Medium	Medium	16 MPa
					TSw2 121-175 MPa	Medium	Medium	148 MPa
				Cohesion of rock and angle of internal friction -- intact rock (compressive strength as a function of confining pressure) fining pressure)	TCw cohesion, current mean ±20%	Medium	Low	30-70 MPa
					Angle of internal friction, current mean ±20%	Medium	Low	45°
					PTn cohesion, current mean ±20%	Medium	Low	4-12 MPa
					Angle of internal friction, current mean ±20%	Medium	Low	8-5°

Table 8.3.1.5-2. Preliminary performance allocation for System Element 1.1.2, subsurface (page 4 of 5)

Function or process	Performance measure	Tentative goal	Needed confidence	Performance or design parameter	Tentative goal[a]	Needed confidence	Current confidence	Expected value[b]
Provide physical properties adequate for construction and operation of stable (safe) underground accesses, drifts, emplacement boreholes, and support facilities for normal and credible abnormal conditions (continued)					TSw1 cohesion, current mean (NL & L) ±20%	Medium	Low	11-36 MPa
					Angle of internal friction, current mean (NL&L) ±20%	Medium	Low	12-35°
					TSw2 cohesion, current mean ±20%	Medium	Low	35 MPa
					Angle of internal friction, current mean ±20%	Medium	Low	24°
				Joint normal and shear stiffness properties (fractures)	TSw2		(see footnote e)	
				Joint wall compressive (fracture surfaces)	TSw2		(see footnote e)	
				Joint roughness coefficient (fracture surfaces)	TSw2		(see footnote e)	
				Cohesion and coefficient of friction (fractures)	TSw2 cohesion, current mean ±20%	Medium	Low	0.1 MPa
					Coefficient of friction, current mean ±20%	Medium	Low	0.54
				Number of joint sets	TSw2 2-3	High	Medium	2-3 sets
				Frequency and spacing	TSw2 20-40/m^3	Medium	Medium	20-40/m^3
				Joint orientation	TSw2 identify joint sets and orientation	Medium	Medium	Cannot be estimated based on current data
				Joint roughness and condition of joints	TSw2 discontinuous to smooth undulating	Medium	Medium	Rough, undulating
				Rock quality designation	TSw2 80-35	Medium	Medium	80-35
				Joint alteration	TSw2 softening or low friction with clay mineral coatings	Medium	Medium	Unaltered to slightly altered

Table 8.3.2.5-2. Preliminary performance allocation for System Element 1.1.2, subsurface (page 5 of 5)

Function or process	Performance measure	Tentative goal	Needed confidence	Performance or design parameter	Tentative goal[a]	Needed confidence	Current confidence	Expected value[b]
				Construction method	No site data required			
Provide physical properties adequate for construction and operation of stable (safe) Underground accesses, drifts, emplacement boreholes, and support facilities for normal and credible abnormal conditions (continued)				Presence of swelling or squeezing ground	Not present based on current data			
				Water inflow	Quantify water inflow	Medium	High	Not expected
				Expected seismic loading	0.2-0.3g acceleration	Medium	Low	0.2-0.3g (underground)
				Description and frequency of abnormal conditions in rock-mass	TBD	TBD	TBD	TBD
				Fault properties (subsurface)				
				Location	Actual location to accuracy of ±5 m	High	Low	Location within 5 m
				Orientation	Actual orientation to accuracy of ±10°	Medium	Medium	Orientation to within 10°
				Physical, thermal, and mechanical properties of major faults	Offset ±2 m Spacing ±1 m Fill characteristics	High	Low	Cannot be estimated based on current data
Dissipate heat from emplaced waste	Waste package temperature	Centerline temperature of waste package <350°C	High	Initial formation temperature	See values specified under rock properties in primary area			
				Thermal conductivity of rock	See values specified under rock properties in primary area			
				Heat capacity of rock	See values specified under rock properties in primary area			
Provide adequate water for repository operations	Available water	Water availability >400 acre-ft per yr	High	Sustained yield of pumped water source for operational support	400 acre ft/yr	Medium	Medium	>400 acre ft/yr

[a]Where the goal is indicated as a percentage of the current mean value, the goal is to show that the distribution of the new data is similar to that of the current data and that the mean value of the new data lies within the range specified as percentage of the current mean value. The goals are based on current values used for repository conceptual design and supporting analyses (Tables 6-11 through 6-16) and limited sensitivity analyses reported in Appendix I of the Site Characterization Plan-Conceptual Design Report (SNL, 1987) and in Ehgartner (1987).

[b]In general the expected value is provided to indicate the range of typical values measured to date. This column is not intended to identify the limits of all values measured to date nor is it intended to indicate that the design would be invalid if future values obtained differ from the values presented.

[c]NL denotes properties for nonlithophysal.

[d]L denotes properties for lithophysal.

[e]Existing data are insufficient to establish goals or expected values.

Table 8.3.2.5-3. Preliminary performance allocation for system element 1.2.1.1, access construction (page 1 of 4)

Function or process	Performance measure	Tentative goal	Needed confidence	Performance or design parameter	Tentative goal	Needed confidence	Current confidence	Expected value
Underground facility access for personnel, support materials, waste handling systems during construction, operation (including retrieval), and decommissioning	Accesses (shafts and ramps) usable for 100 yr with reasonable maintenance	Access to construct, emplace, and retrieve waste, close, and decommission for 100 yr	High	The parameters required, the tentative goals, and confidence required for these parameters are the same as those listed under System Element 1.1.2 subsurface, under rock properties in primary area				
	Compliance with 10 CFR 60.133f	Limit rock damage during construction		The parameters required, the tentative goals, and confidence required for these parameters are the same as those listed under System Element 1.1.2 subsurface, under rock properties in primary area				
		Overbreak <6 in. average	Medium					
		Extent of fracturing of intact rock <3 m average	Medium					
	Access closure (combined performance of rock and opening support system)	Extent of closure <1 mm/yr in accesses (shafts and ramps)	Medium	The parameters required, the tentative goals, and confidence required for these parameters are the same as those listed under System Element 1.1.2 subsurface, under rock properties in primary area				
		Total closure <6 in. in 100 yr (ramps)	Medium					
		Total closure <3 in. in 100 yr (shafts)	Medium					
	Rockfall	Rockfall <5 ton (average) per 1,000 ft of length per yr (ramps)	Medium	The parameters required, the tentative goals, and confidence required for these parameters are the same as those listed under System Element 1.1.2 subsurface, under rock properties in primary area				
		Maximum size of rock or slabfall <2 tons	Medium					
		Rockfall contained by support system (ramps)	Medium					
		No rockfall to disrupt or damage waste transporter (ramp)	Medium					

Table 8.3.2.5-3. Preliminary performance allocation for system element 1.2.1.1, access construction (page 2 of 4)

Function or process	Performance measure	Tentative Goal	Needed confidence	Performance or design parameter	Tentative goal	Needed confidence	Current confidence	Expected value
Underground facility access (continued)		Rockfall or liner spall in shafts <1 ton (average) per 1,000 ft/yr	Medium					
		All rockfall or liner spall in shaft to be retained (by supplemental support system, supplemental liner or other methods)	High					
	Maintenance frequency	Inspection and maintenance frequency		The parameters required, the tentative goals, and confidence required for these parameters are the same as those listed under System Element 1.1.2 subsurface, under rock properties in primary area				
		Inspection and minor maintenance done on continuing basis	Medium					
		Major maintenance frequency <25 yr	Medium					
	Access sizes and grades compatible with requirements for personnel and material transport and utility routing	Size			No site characterization data required			
		20 ft clear diameter man and material shaft to accommodate man and material cage of required capacity and utilities	Medium					
		19 ft diameter waste ramp roadway width 5 ft > width of waste transporter. Minimum vehicle clearance >2 ft	Medium					

Table 8.3.2.5-3. Preliminary performance allocation for system element 1.2.1.1, access construction (page 3 of 4)

Function or process	Performance measure	Tentative Goal	Needed confidence	Performance or design parameter	Tentative goal	Needed confidence	Current confidence	Expected value
Underground facility access (continued)		20 ft diameter tuff ramp clearance adequate for tuff conveyor, movement of major construction equipment and utilities	Medium					
		Grades		Elevation at ramp entry ramps	Topographic maps with 1 m contours	Medium	Medium	1 m contours
		Waste ramp grade <10%	High					
		Tuff ramp grade <20%	Medium					
Ventilation routing (supply and exhaust)	Pressure drop in shafts and ramps	Shafts and ramps of sufficient size to limit flow velocities. Size sufficient to provide contingency to cover changes in future air quantity requirements		Pressure drop per unit length of drift	Site data required will be pressure drop measurements made in shafts and ramps constructed in different types of rock. Measurements wills be repeated for each construction method and liner type used.			
		Ramp velocities <1,500 ft/min	Medium					
		Shaft velocities <3,000 ft/min	Medium					
Sealing	Shafts and ramps compatible with requirements for repository sealing	Materials used compatible with sealing requirements	High		Parameters (information needed) have been identified under Issue 1.12, Table 8.3.3-9.			
		Construction methods compatible with sealing requirements	High		No site characterization data required			
		ES-1 shaft liner capable of being removed at time of closure	High		No site characterization data required			

Table 8.3.2.5-3. Preliminary performance allocation for system element 1.2.1.1, access construction (page 4 of 4)

Function or process	Performance measure	Tentative Goal	Needed confidence	Performance or design parameter	Tentative goal	Needed confidence	Current confidence	Expected value
Sealing (continued)		No shaft (except ES-1) should penetrate into Calico Hills unit	High	Elevation of upper Calico Hills	Elevation within 5 m	High	High	At ES-2 = 2,728 ft; at men and materials shaft 2,742 ft; at waste ventilation shaft 2,806 ft
		Water storage capacity at base of shafts (excluding ES-2) to be 150 m^3	High		No site characterization data required			
		The thickness between the bottom of ES-1 or any exploratory studies facility (ESF) drifting and the ground-water table should be greater than the minimum thickness of the Calico Hills above the water table anywhere within the repository boundary	High	Ground water table 2,400 ft elevation at ES-1		High	High	2,400 ft

Table 8.3.2.5-4. Preliminary performance allocation for System Element 1.2.1.2, drift construction (page 1 of 2)

Function or process	Performance measure	Tentative goal	Needed confidence	Performance or design parameter	Tentative goal	Needed confidence	Current confidence	Expected value
Underground facility access for personnel, support materials, waste handling systems during construction, operation (including retrieval), and decommissioning	Drifts usable for 100 yr with reasonable maintenance	Access to construct, emplace and retrieve waste, close and decommission for 100 yr	High	The parameters required for these performance goals for System Element 1.2.1.2 are the same as specifed under rock properties in primary areas under System Element 1.1.2 (subsurface)				
	Compliance with 10 CFR 60.133f	Limit rock damage during construction		The parameters required for these performance goals for System Element 1.2.1.2 are the same as specified under rock properties in primary areas under System Element 1.1.2 (subsurface)				
		Overbreak <6 in. average	Medium					
		Extent of fracturing in intact rock <3 m	Medium					
	Drift closure (combined performance of rock and rock support system)	Extent of closure		The parameters required for these performance goals for System Element 1.2.1.2 are the same as specified under rock properties in primary areas under System Element 1.1.2 (subsurface)				
		<1 mm/yr in main and access drifts	Medium					
		<3 mm/yr in waste emplacement drifts	Medium					
		Total closure <6 in. in 100 yr for all drifts	Medium					
	Rock fall (performance of rock support system)	Rockfall		The parameters required for these performance goals for System Element 1.2.1.2 are the same as specified under rock properties in primary areas under System Element 1.1.2 (subsurface)				
		<5 ton (average) per 1,000 ft of drift per yr	Medium					
		Rockfall contained by support system	High					
		Maximum size of rock or slab fall <2 tons	Medium					
		No rockfall sufficient to disrupt or damage waste transporter	Medium					
	Acceptable maintenance frequency	Frequency		The parameters required for these performance goals for System Element 1.2.1.2 are the same as specified under rock properties in primary areas under System Element 1.1.2 (subsurface)				
		Inspection and minor maintenance will be done on a continuing basis	High					

Table 8.3.2.5-4. Preliminary performance allocation for System Element 1.2.1.2, drift construction (page 2 of 2)

Function or process	Performance measure	Tentative goal	Needed confidence	Performance or design parameter	Tentative goal	Needed confidence	Current confidence	Expected value
Underground facility access (continued)		Major maintenance frequency >25 yr	High				Medium	
	Drift sizes and slopes compatible with requirements for personnel and material transport and utility routing	Drift cross-section 6 ft greater than maximum mobile equipment width	Medium	No site characterization data required				
		Drift grades <8%	High	Upper and lower contact elevations for the TSw2 formation over the entire repository area	Upper and lower contact elevations for the TSw2 within 20 m	Medium		Elevations accurate to ±20 m
Ventilation routing (supply and exhaust)	Pressure drop in drifts	Drifts of sufficient size to limit air velocities to <2,000 ft/min	Medium	No additional site characterization data required. Site data requirements related to nonradiological health and safety are identified in Table 8.3.2.5-8 under System Element 1.2.1.1, mining ventilation				
Sealing	Drifts (underground layout) compatible with repository sealing	Underground drift layout and grades should provide water drainage from waste emplacement to designated nonemplacement drifts	High	Upper and lower contact elevations for the TSw2 formation within the potential repository area	Upper and lower contact elevations for the TSw2 within 20 m	Medium	Medium	Elevations accurate to ±20 m
		Drift layout and and grades within the exploratory studies facility should drain to the ES-1 shaft	High	Upper and lower contact elevations for the TSw2 formation within the potential repository area	Upper and lower contact elevations for the TSw2 within 20 m	Medium	Medium	Elevations accurate to ±20 m

Table 8.3.2.5-5. Preliminary performance allocation for System Element 1.2.1.3, borehole construction

Function/ process	Performance measure	Tentative goal	Needed Confidence	Performance or design parameter	Tentative goal[a]	Needed confidence	Current confidence	Expected value
Provide for emplacement	Constructability of usable borehole for waste disposal envelope	25 ft deep x 29 in. diameter vertical borehole	High	Abrasiveness of rock	Reasonable cutter life	Medium	Medium	Cannot be estimated based on current data
		363 ft long x 36 in. diameter horizontal borehole	High	The additional parameters required to access constructability of usable boreholes are the rock parameters identified under System Element 1.1.1 (subsurface)				
Provide waste emplacement	Installation of borehole liner	Ability to install vertical hole liner	High	Mechanical system---No additional site characterization data required				
		Ability to install up to 363 ft of horizontal hole liner	High	Mechanical system---Because the longitudinal boreholes are lined as they are drilled, no additional site characterization data required				

[a]Tentative goals, including ranges, for performance or design parameters are based on current reference values used for repository conceptual design and supporting analyses (Tables 6-11 through 6-16), and limited sensitivity analyses reported in Appendix I of the Site Characterization Plan-Conceptual Design Report (SWL, 1987) and its references and in Ehgartner (1966).

Table 8.3.2.5-6 Preliminary performance allocation for System Element 1.2.1.4, rock handling

Function/ process	Performance measure	Tentative goal	Needed confidence	Performance or design parameter	Tentative goal	Needed confidence	Current confidence	Expected value
Removal of mined rock	Ability to remove mined rock at rate of generation	3,000 tons/day	Medium	Size range of blast-fractured rock	Maximum rock size	Low	Low	<12 in.
				Angle of repose of fractured rock piles	Actual angle of repose ±5°	Low	Low	25-30°

Table 8.3.2.5-7. Preliminary performance allocation for System Element 1.2.1.5, water removal

Function/ process	Performance measure	Tentative goal	Needed confidence	Performance or design parameter	Tentative goal	Needed confidence	Current confidence	Expected value
Removal of process water	All process water removed	Removal capacity >600 gph	Medium	Quantity of process water	(a)			
Removal of natural water	Removal rate equal to rate of inflow	Removal capacity >50 gpm	Medium	Natural water inflow	Actual inflow rate to accuracy of ±10 gpm	Medium	Low	<50 gpm
Removal of water resulting from condensation in ventilation returns (potential during operations)	Removal rate equal to rate of condensation	Removal capacity > potential rate of condensation	Medium	Condensate quantity	(b)			

[a]No site characterization data required. Values will be developed in the plan for repository design.
[b]Condensate potential and quantities will be determined using parameters specified in System Elements 1.1.2 (subsurface), 1.2.1.6 (mine ventilation), and 1.2.2.7 (waste handling ventilation).

Table 8.3.2.5-8. Preliminary performance allocation for System Element 1.2.1.6, mining ventilation (page 1 of 2)

Function or process	Performance measure	Tentative goal	Needed confidence	Performance or design parameter	Tentative goal	Needed confidence	Current confidence	Expected value
Supply quality air to working area (considering: temperature, humidity, dust content, and other pollutants)	Compliance with 30 CFR Part 57	125 ft^3/min per unit diesel horsepower in use	High	In situ temperature of host rock	TSw2 23-25°C	Medium	Medium	23-25°C
	Compliance with threshold limit values and biological exposure indices specified in ACGIH[a] (1986)	Normal operation air cooling power = 300 w/m^2 at 45°C (dry bulb)	High	Diurnal temperature and humidity variation of ambient air at intake and exhaust locations	Temperature/ humidity vs. time-of-day plots for year (based on historical data)	No site characterization data required. Existing data sufficient when normalized to site		
		210 ft^3/min per worker	High	Seasonal temperature and humidity variation of ambient air at intake and exhaust locations	Temperature/ humidity vs. time-of-day plots for year (based on historical data)	No site characterization data required. Existing data sufficient when normalized to site		
		60 ft/min minimum air velocity in work areas	High					
				Surface topography at intake and exhaust locations	Topographic maps with 1 m contours	Medium	Medium	1 m contours
				Pressure drop/unit length of accesses or drifts	Actual pressure drop for rock exhibiting different surface characteristics and for each method of construction	Low	Low	(b)
		Silicon dioxide particulate concentration <0.1 mg/m^3	High	Rock chemistry	Potential for SiO_2	Medium	Medium	SiO_2 content of rock
				Dust generation potential for mining and drilling operations	Particulate size and quantity data	Medium	Medium	(c)
		Oxygen concentration >19.5 volume percent	High	Equipment type and utilization times	No site characterization data required			
		Radon daughter concentration <1.0 working level (WL) in active working area (Issues 2.2 and 2.7)	High	Potential for radon	Rock uranium content	Medium	Medium	(c)
				Radon emission rate from rock	Radon emission rate	Medium	Medium	(c)

Table 8.3.2.5-8. Preliminary performance allocation for System Element 1.2.1.6, mining ventilation (page 2 of 2)

Function or process	Performance measure	Tentative goal	Needed confidence	Performance or design parameter	Tentative goal	Needed confidence	Current confidence	Expected value
Supply quality air to working area (considering: temperature, humidity, dust content, and other pollutants) (continued)		Personnel exposure to radon daughters <4 WL months (Issues 2.2 and 2.7)	High	Potential for radon	Rock uranium content	Medium	Medium	(c)
				Radon emission rate from rock	Radon emission rate	Medium	Medium	(c)
Provide flexibility to allow changes in air quantities and routing	System design flexibility to allow changes in air quantities and routing	Flexibility in design of layout and flow control features (regulators and stoppings)	High	Underground design	No site characterization data required			
Provide safe escape routes for work force	Ventilated escape routes available for all active work areas	Ventilated escape routes provided by design	High	Underground design operation plan	No site characterization data required			
Provide independence between ventilation systems	Compliance with 10 CFR 60.133(g)	Drift layout and contructed features (bulkheads, airlocks, etc.) designed to ensure independence of systems	High	Underground design	No site characterization data required			
		Leakage to be from mining ventilation to waste emplacement ventilation system	High	Permeability of disturbed rock	Permeability of rock affected by mining operations (blasting)	Low	Low	(c)
				Pressure differentials between systems	No site characterization data required			

[a]ACGIH = American Conference of Governmental Industrial Hygienists.
[b]No estimate available. Values used to this point for ventilation calculations have been based on handbook information.
[c]Cannot be estimated based on currently available data.

Table 8.3.2.5-9. Preliminary performance allocation for System Element 1.2.2.4, emplacement

Function or process	Performance measure	Tentative goal	Needed confidence	Performance or design parameter	Tentative goal	Needed confidence	Current confidence	Expected value
Transport waste to emplacement location	Ability to transport the required number of waste packages per day using methods that will ensure personnel safety	Transport 10 packages per day	High	Mechanical activity--no site characterization data required				
		Nonradiological safety (Issue 4.2)	High	Parameters pertinent to nonradiological safety that are dependent on site characteristics are presented under System Element 1.2.1.1 (access construction) and System Element 1.2.1.2 (drift construction)				
	Compliance with ALARA[a]	Radiological safety (see Issue 2.7 for radiological safety goals, Issue 2.2 for normal conditions, and Issue 2.3 for accident conditions)	High	Parameters pertinent to radiological safety that are dependent on site characteristics are presented under System Element 1.2.2.5 (retrieval)				
	Compliance with other requirements relating to worker radiation dose[b]							

[a]ALARA = as low as reasonably achievable.
[b]The goals and parameters required to develop assurance of worker radiological safety are discussed and presented in detail in Sections 8.3.5.4, 8.3.5.5, and 8.3.2.3.

Table 8.3.2.5-10. Preliminary performance allocation for System Element 1.2.2.5, retrieval

Function or process	Performance measure	Tentative goal	Needed confidence	Performance or design parameter	Tentative goal	Needed confidence	Current confidence	Expected value
Retrieval of emplaced waste	Access to emplacement borehole	Access available for 100 yr with reasonable maintenance of accesses and drifts	High	Access to the emplaced waste for retrieval will be ensured by setting the goals for rock damage, closure, and rockfall stipulated in Systems Elements 1.2.1.1 (access construction) and 1.2.1.2 (drift construction). The parameters needed to predict performance of the accesses and the drifts are specified in System Element 1.1.2 (subsurface)				
	Access to waste package	Rock temperature at borehole wall <275°C	Medium	Access to the emplaced waste for retrieval will be ensured by meeting the goals for rock damage, closure, and rockfall stipulated in Systems Elements 1.2.1.1 (access construction) and 1.2.1.2 (drift construction). The parameters needed to predict performance of the accesses and the drifts are specified in System Element 1.1.2 (subsurface)				
		Borehole liner deformation <2 in. vertical emplacement, <3 in. for horizontal emplacement (in 100 yr)	Medium	Access to the emplaced waste for retrieval will be ensured by meeting the goals for rock damage, closure, and rockfall stipulated in Systems Elements 1.2.1.1 (access construction) and 1.2.1.2 (drift construction). The parameters needed to predict performance of the accesses and the drifts are specified in System Element 1.1.2 (subsurface)				
		Liner corrosion <1/2 liner thickness in 100 yr	Medium	Water and formation chemistry	Quantitative and qualitative analysis of formation and water	Medium	Medium	Cannot be estimated based on current data
Waste retrieval	Retrieval time	Retrieval time < emplacement time plus construction time	Medium	Operations plan	No site characterization data required			
	Operator safety	Radiation dose rate for retrieval operations personnel <1 rem/yr	High	Radiation shielding characteristics of rock	Attenuation factors for neutron and gamma radiation	Medium	Medium	Cannot be estimated based on current data
Waste transport	Operator safety	Radiological safety[a]	High	Radiation shielding characteristics of rock	Attenuation factors for neutron and gamma radiation	Medium	Medium	Cannot be estimated based on current data
		Nonradiological safety[a]	High	Operations plan	No site characterization data required			

[a]The goals and parameters needed to develop assurance of worker radiological safety are identified and discussed in detail in Sections 8.3.5.4, 8.3.5.5, and 8.3.2.3.

Table 8.3.2.5-11. Preliminary performance allocation for System Element 1.2.2.7, waste handling ventilation

Function/ process	Performance measure	Tentative goal	Needed confidence	Performance or design parameter	Tentative goal	Needed confidence	Current confidence	Expected value
Supply air to waste disposal areas during emplacement and retrieval	The performance measures, goals, and needed confidences for this function are the same as for System Element 1.2.1.6 (mining ventilation) except for the addition of cooling requirements to provide for retrieval of waste packages from heated drifts, the additional requirement is			Site data required for this System Element is the same as the data required by System Element 1.2.1.6				
	Air cooling power for retrieval or preparation	Air cooling power for retrieval or retrieval preparation = 500 W/m^2 at 40°C (Dry Bulb)	High					
Radiological safety	Detection of airborne radioactive material	Immediate detection of airborne radioactive materials	High					
	Reduction and redirection of vent flows in the event that airborne radioactive particulate is detected	Reduction of ventilation flow by 50%	High					
		Diversion of ventilation flow to filter system	High					
Provide flexibility to allow changes in air quantities and routing necessary to accommodate changes in requirements	Performance measures and goals are the same as System Element 1.2.1.6 (mining ventilation)							
Provide safe escape routes for work force	Performance measures and goals are the same as System Element 1.2.1.6 (mining ventilation)							
Provide independence between ventilation systems	Performance measures and goals are the same as System Element 1.2.1.6 (mining ventilation)							

Table 8.3.2.5-12. Preliminary performance allocation for System Element 1.2.4.1, underground closure

Function/ process	Performance measure	Tentative goal	Needed confidence	Performance or design parameter	Tentative goal	Needed confidence	Current confidence	Expected value
Removal of repository structures	Compliance with requirements for decommissioning	Decommissioning operations and designs compatible with postclosure requirements	High	Parameters needed are identified in System Elements 1.1.1 (surface) and 1.1.2 (subsurface). Requirements will be identified in the decommissioning section of the operations plan and the repository design plan				
Installation of seals	Compliance with requirements for postclosure seals	Preclosure designs compatible with requirements for postclosure seal installation	High	Parameters required are identified in System Elements 1.1.2 (subsurface), 1.2.1.1 (access construction), and 1.2.1.2 (drift construction), and Issue 1.12, Table 8.3.3-8				
		Preclosure and decommissioning materials compatible with postclosure seals	High	Parameters required are identified in System Elements 1.1.2 (subsurface), 1.2.1.1 (access construction), and 1.2.1.2 (drift construction), and Issue 1.12, Table 8.3.3-8				
		Seals installed per requirements of sealing program	High	Parameters required are identified in System Elements 1.1.2 (subsurface), 1.2.1.1 (access construction), and 1.2.1.2 (drift construction), and Issue 1.12, Table 8.3.3-8				
Installation of surface markers	Marker permanence	Marker lifetimes equal to requirements	Medium	Parameters needed are identified in System Elements 1.1.1 (surface) and 1.1.2 (subsurface). Requirements will be identified in the decommissioning section of the operations plan and the repository design plan				
Construction of diversion structures or water flow barriers	Construction according to sealing requirements	Lifetime and material requirements met	Medium	Parameters needed are identified in System Elements 1.1.1 (surface) and 1.1.2 (subsurface). Requirements will be identified in the decommissioning section of the operations plan and the repository design plan				
Installation of backfill	Filling of all underground openings	Openings filled with materials acceptable to waste package performance requirements	High	Parameters required are identified in System Elements 1.1.2 (subsurface), 1.2.1.1 (access construction), and 1.2.1.2 (drift construction), and Issue 1.12, Table 8.3.3-8				
		Openings filled with materials meeting sealing requirements	High	Parameters required are identified in System Elements 1.1.2 (subsurface), 1.2.1.1 (access construction), and 1.2.1.2 (drift construction), and Issue 1.12, Table 8.3.3-8				