See folder for Ltr. Sum. Meeting Notes and workshop handouts 1/4/84

SUMMARY MEETING NOTES

BWIP/NRC WORKSHOP ON UNDERGROUND TEST PLAN

Richland, Washington
November 29-December 2, 1983

Objectives: See Attachment 1

Agenda: See Attachment 1

Attendees: See Attachment 1 and 2

Developments:

The workshop centered on preliminary comments by Nuclear Regulatory Commission (NRC) on the Draft Exploratory Shaft (ES) Test Plan (2 volumes) SD-BWI-TP-007, dated November 9, 1983. The comments were directed toward the suitability of the test plan in satisfying licensing information needs, in the event that the Basalt Waste Isolation Project (BWIP) site is submitted to the NRC for licensing.

These summary notes provide general comments presented at the meeting by NRC and by BWIP, as well as a list of open items. Additional comments by NRC appear in Attachment 3. Attachment 4 presents material prepared by Department of Energy (DOE) and related to the underground test plan that was discussed during the meeting. Attachment 5 is a "Test Logic Diagram" presented by the NRC as an illustrative example of logic useful for structuring the Test Plan. Attachment 6 provides a table of questions on coupled behavior that was presented by NRC for discussion.

NRC General Comments:

1. If a construction authorization application is submitted for the BWIP, that application must be complete and fully supported by the data and analysis necessary for a licensing decision on whether the site and design comply with the performance objectives and criteria contained in 10 CFR 60. Fundamental test results for the construction application findings must be in place at the time of license application.

8401260010 840104
PDR WASTE
WM-10 PDR

2. The draft ES Test Plan is inadequate in expressing the application of test data to modeling and performance assessment. We suggest that the report should set out a clear connection between the site performance issues and the remaining information needed to address them. This requires:

   a. A discussion of the performance issues, and the way in which they have been identified.
   b. A discussion of the proposed investigation approach to obtaining the required information.
   c. A discussion of the way in which the results of these investigations will be used to address the site performance issues.

   The report should, therefore, provide more complete material on "justifications of need for additional data and proper selection of tests" and "identification of data applications to modeling and performance assessment" (SD-BWI-TP-007, Volume I, page 2).

3. A critical part of the site characterization effort is the development of an understanding of the coupled thermal-mechanical-hydrologic-geochemical behavior of the repository host rock. Nuclear Regulatory Commission has expressed this view several times in the past twelve months (SCA, 1983; DOE, Headquarters, 1983; Advisory Committee on Reactor Safety, 1983). It is necessary for the test plan to include a description of how the information collected will address this issue, or what other kind of information will be used to address this question.

4. During the workshop there were a number of topics (e.g., retrievability, sealing and waste package testing) on which DOE and NRC do not have agreement about whether testing is required prior to License Application. Basalt Waste Isolation Project identified that

these tests could be put off until after License Application (Attachment 4, Section 17.2.8, page 17.2-29). Each of these topics needs to be addressed on its own merits. The NRC has serious concerns about putting off tests that could be needed to support a License Application.

Nuclear Regulatory Commission noted that Subpart F - Performance Confirmation Program, Section 10 CFR 60.140 general requirements, includes provisions for determining subsurface conditions and changes assumed in the licensing review and for obtaining data to confirm functional performance of natural and engineered systems. Section 60.140 requires that the performance confirmation program be started during site characterization and continue through permanent closure and that it include in situ experimentation and monitoring as is appropriate.

5. The workshop did not explicitly include discussion of tests involving performance objectives for the engineered systems. We consider such testing could influence the in situ testing currently planned by the DOE. This matter will be considered at the design and waste package workshop early in 1984.

6. We are pleased to see that BWIP is investigating ways to enhance the amount of time available for in situ testing (e.g., contingency for a second shaft).

7. While progress is being made in making site characterization information available to NRC and other interested parties, this effort needs continued project attention. All such data must be made available as soon as possible.

8. We recommend that two additional objectives be added to Table 3-1. These are:

   a. Control any adverse radiological, safety-related effects from shaft construction; Reference: 10 CFR 60.11 (a) (6) (iii).
   b. Perform preliminary characterization of the RRL block.

BWIP General Comments:

1. A data needs assessment should be provided for each item to establish necessary and sufficient conditions. The assessments would consider data use in performance assessment and design.

2. Basalt Waste Isolation Project logic for the site characterization program and the relationship of the ES to the other program elements needs to be explained.

3. Allocation of tests to Phase II and Design Confirmation must be based on rationale developed from future dialogue with the NRC.

4. The NRC concern relative to tests which impact the Nuclear Waste Terminal Storage (NWTS) program, such as the coupled (thermal/mechanical/hydrologic/geochemical) test, isolation sealing, retrievability and backfill capabilities will be referred to DOE, Headquarters for coordination of an overall NWTS program approach.

5. The attached updated BWIP responses to previous Draft Site Characterization Analysis comments will be incorporated into the next revision of the "disposition tables."

Open Items:

1. The NRC will provide written, follow-up comments on the Underground Test Plan by the end of January 1984.

2. A technical assistance report on retrieval alternatives, completed for NRC, will be provided to the DOE shortly.

3. The DOE was requested to provide NRC with information on six case histories of mining through rock showing discing in exploratory boreholes.

4. The DOE will provide NRC with hydrological test interval reports that have been developed after July 1982.

O. L. Olson, DOE-RL
December 2, 1983

Robert J. Wright, NRC
December 2, 1983

Attachment 1

11/29/83
REVISED
AGENDA
DOE/NRC MEETING ON
EXPLORATORY SHAFT AND UNDERGROUND TESTING
BASALT WASTE ISOLATION PROJECT

Date: November 29 to December 2, 1983

Place: Richland, Washington, Hanford House

Purpose: To discuss resolution of previous NRC concerns regarding underground testing portions of the Site Characterization Report and NRC's preliminary comments on the draft Exploratory Shaft In Situ Test Plan.

Objectives:

(1) To discuss NRC comments regarding underground testing raised in the Draft Site Characterization Analysis.

(2) To discuss approaches to resolve previously noted areas of disagreement.

(3) To receive and discuss NRC's preliminary comments arising from a recent review of the draft Exploratory Shaft Test Plan.

Participants:

DOE: P. Boileau, V. Der, J. Mecca, C. Newton, P. Saget, D. Squires, J. N. Fiore

DOE Consultants: J. Bartlett, Z. Bieniawski, W. Hustrulid, J. Smith

NRC: N. M. Coleman, L. Doyle, P. K. Dutta, J. Greeves, M. S. Nataraja, C. Russell, C. Westbrook, R. J. Wright, E. Zurflueh

NRC Consultants: A. Brown, J. Daeman, D. Galster, L. Ganano, L. Mundell, V. Rajaram, J. Rowe, M. Serbousek, K. Wahi, R. Williams, G. Winter

Rockwell: R. J. Bielefeld, H. B. Dietz, R. E. Gephart, K. A. Hadley, J. F. Marron, W. M. McCabe, T. M. Wintczak

USGS: P. Stevens, A. LaSalla

Other Attendees:

State of Washington: D. Provost

Yakima Indian Nation: J. Hovis, L. Lehman

NNWSI: D. Nelson, W. Myers

MK: B. R. Bush, J. J. Keating, S. Iedema, F. C. Larvie

ONWI: M. H. Farzin, L. B. Myers

Weston: V. Montenyohl, N. Saidman

NOVEMBER 29, 1983

8:00 DOE Introduction

8:15 NRC Introduction

8:30 BWIP overview of Exploratory Shaft In Situ Test Plan:

- Preparation process and schedule, including current status and revisions planned to accommodate comments received from the Overview Committee and others.
- Methodology for resolving open, workshop, and "agreed" items resulting from BWIP's dispositioning of NRC comments on underground testing raised in the Draft Site Characterization Analysis.
- Test Plan's responsiveness to open, workshop, and "agreed" items.

11:20 NRC/BWIP discussion of thermal coupled effects

12:00 Lunch

1:00 Discuss NRC's preliminary comments on draft In Situ Test Plan

- Geology
- Hydrology

NOVEMBER 30, 1983

8:00 Continue discussion of NRC's preliminary comments

- Geology
- Hydrology

12:00 Lunch

1:00 Continue discussion of NRC's preliminary comments

- Geomechanics
- Constructibility

DECEMBER 1, 1983

8:00 Continue discussion of NRC's preliminary comments

- Geomechanics
- Constructibility

12:00	Lunch
1:00	NRC caucus/BWIP caucus
3:00	BWIP present disagreements and agreements
3:30	NRC present disagreements and agreements
4:00	BWIP/NRC develop list of disagreements and agreements

DECEMBER 2, 1983

8:00	Technical wrap-up
10:00	Management wrap-up
11:00	Preparation of meeting notes

Attachment 2

DOE/NRC WORKSHOP

Attendees

Name	Representing	Name	Representing
Karl A. Hadley	Rockwell	Tom McLaughlin	Rockwell
John F. Marron	Rockwell	F. C. Larvie	M-K
Tom M. Wintczak	Rockwell	Carl Newton	DOE
Brad R. Bush	M-K	Harry Babad	Rockwell
John J. Keating	M-K	W. Martin McCabe	Rockwell
Lynn B. Myers	ONWI	Chris Bohrn	Rockwell
R. P. Saget	DOE	Victor Der	DOE-HQ
D. J. Squires	DOE-RL	Phil Long	Rockwell
H. B. Dietz	Rockwell	James B. Hovis	YIN
Bill Hustrulid	CSM/DOE	Dean Nelson	LANL
W. A. Herber	Rockwell	Wes Myers	LANL
Stuart Iedema	M-K	Ron Arnett	Rockwell
L. T. Murphy	Rockwell	Kunsoo Kim	Rockwell
Larry Fitch	Rockwell	Peter Stevens	USGS
Roy Gephart	Rockwell	Roy E. William	NRC
Vic Montenyohl	Weston	Catherine Russell	NRC
M. Saidman	Weston	Kristin Westbrook	NRC
J. N. Fiore	DOE/NV	B.C.K. Moravek	Rockwell
Robert Wright	NRC	F. R. Cook	NRC
F. L. Doyle	NRC	M. OL Serbousek	USBM
Emma Zurflueh	NRC	R. J. Bielefeld	Rockwell
John Greeves	NRC	J. H. LaRue	Rockwell
Jank Daemen	NRC	S. M. Baker	Rockwell
Lou Gowano	Golder/NRC	S. R. Strait	Rockwell
Adrian Brown	NRC	Don Prouost	Weston
V. Rajabram	NRC	Richard W. Galster	NRC
Gerry Winter	NRC	Hassan Farzin	ONWI
Kris Walin	NRC	Lawrence A. White	Weston
Neil Coleman	NRC	George C. Evans	Rockwell
Peyush Dutta	NRC	R. T. Wilde	Rockwell
Jerry Rowe	Golder/NRC	A. M. LaSala, Jr.	USGS
M. S. Nataraja (Raj)	NRC	P. L. Boileau	DOE
Ed Ash	Rockwell	J. E. Mecca	DOE
Dick Bieniawski	DOE	A. M. Tallman	Rockwell
Linda Lehman	YIN	R. T. Wilde	Rockwell
Jan Partricio	Rockwell	J. T. Baxter	Rockwell
John Bartlett	DOE	G. S. Hunt	Rockwell
Jay L. Smith	DOE		

NUCLEAR REGULATORY COMMISSION
PRELIMINARY COMMENTS PROVIDED DURING
THE WORKSHOP

GEOMECHANICS

1. The Department of Energy (DOE) should provide in the Exploratory Shaft (ES) Test Plan the rationale for the development of data needs that are essential for site characterization, the repository design and performance assessment. The revised ES Test Plan document should provide justification for the proposed tests in terms of necessary and sufficient data for the License Application (LA).

2. Sensitivity analyses should be conducted to determine the relative importance of the design parameters and the needed levels of accuracy and confidence in the proposed tests.

3. A glossary should be provided in the ES Test Plan. A detailed discussion should be provided to clearly define, for example, the following: a) rock mass strength; b) failure; c) failure criteria; d) excessive deformation; e) overstressing; f) stability; g) stability criteria. Time effects should be considered explicitly in each discussion.

4. The revised Test Plan document should contain discussions on the manner in which data from the Near-Surface Test Facility (NSTF) and ES will be integrated and extrapolated to the reference repository location (RRL) block.

5. Details on the ongoing tests on packing material should be provided to the Nuclear Regulatory Commission (NRC) when available. If a decision is made to take credit for the packing in meeting the release rate criteria, the NRC recommends that tests on packing be considered in the ES Test Plan. This should be discussed in the February Waste Package meeting.

6. Objectives of ES-Phase I (ES-I) should be expanded to include:
   a) control of any adverse effects during ES activities; and
   b) preliminary characterization of the RRL block. The disturbed rock zone along the shaft and drifts needs to be addressed in terms of isolation performance.

7. A list of tests that are considered to be design confirmation tests should be provided by the Basalt Waste Isolation Project (BWIP). The rationale behind such thinking should be discussed in the revised Test Plan document.

8. Retrievability demonstration tests are considered important by the NRC, especially if the horizontal emplacement concept is chosen in the final BWIP design. The NRC recommends consideration of retrieval demonstration for the horizontal concept in the ES. This should be discussed in the planned January 1984 Design workshop.

9. The ES Test Plan does not explicity address coupled thermal effects (interaction among thermal, mechanical, hydrological and chemical effects). Information is needed on the effects of heat, deformation and stress on hydrological properties as part of site characterization.

HYDROLOGY

1. The standard analytical techniques described on Page 3-45, Volume II, may not be appropriate to analyze proposed borehole tests. The Department of Energy should consider alternate analytic and numeric methods.

2. Potential interference effects caused by the concurrent tests and by the presence of the drifts and shaft will be considered in test design.

3. The Department of Energy should consider alternate borehole configurations for the cluster tests (e.g., parallel sets of holes in a horizontal planar configuration for specifically testing vertical hydraulic conductivity).

4. The alternative of (examining rock obtained from cores) in the tracer test area (in order) to evaluate tracer movement should be considered.

5. The potential effects of matrix diffusion on tracer movement should be considered.

6. The Department of Energy should be more specific about the directional property of the term "hydraulic conductivity" as used in the text of the test plan.

7. The rationale for the need to test the Cohassett interior, as expressed in the workshop, is understood to be:
   - isolation potential
   - generic information for extrapolation to other flow interiors
   - constructibility

8. The hydrologic character of the repository horizon depends on the stages of the repository:
   - pre-excavation
   - post-excavation, pre-closure
   - post-closure

   If the host horizon is to be considered a barrier by DOE, NRC recommends that containment performance in the third stage must be evaluated.

GEOLOGY

1. Geologic mapping should be objective. The plan is not clear on this point because it mentions "objective" and "subjective" surveys (page 2-2). All data from the drifts should be recorded without interpretation. Procedures for geologists to have constant access to the working face of drifts are needed. Water for cleaning walls is also needed to get early data on the wall conditions, such as discontinuities and evidence of stress release to base decisions on types of ground support.

2. The contingency plan on page 2-46 of Volume II indicates that thickness of the interior of the candidate horizon flow is crucial to siting a repository. However, it also seems that discontinuities or lateral changes in flow properties could also represent unfavorable conditions. An analysis of such factors by use of all available data showing "dense interior" variations should be included in the plan.

3. Use of wireline drilling equipment should be considered. BWIP is presently testing best methods of drilling (standard versus wireline) in NSTF.

4. BWIP should consider coring of all borings in shaft walls unless heavy water flows are encountered.

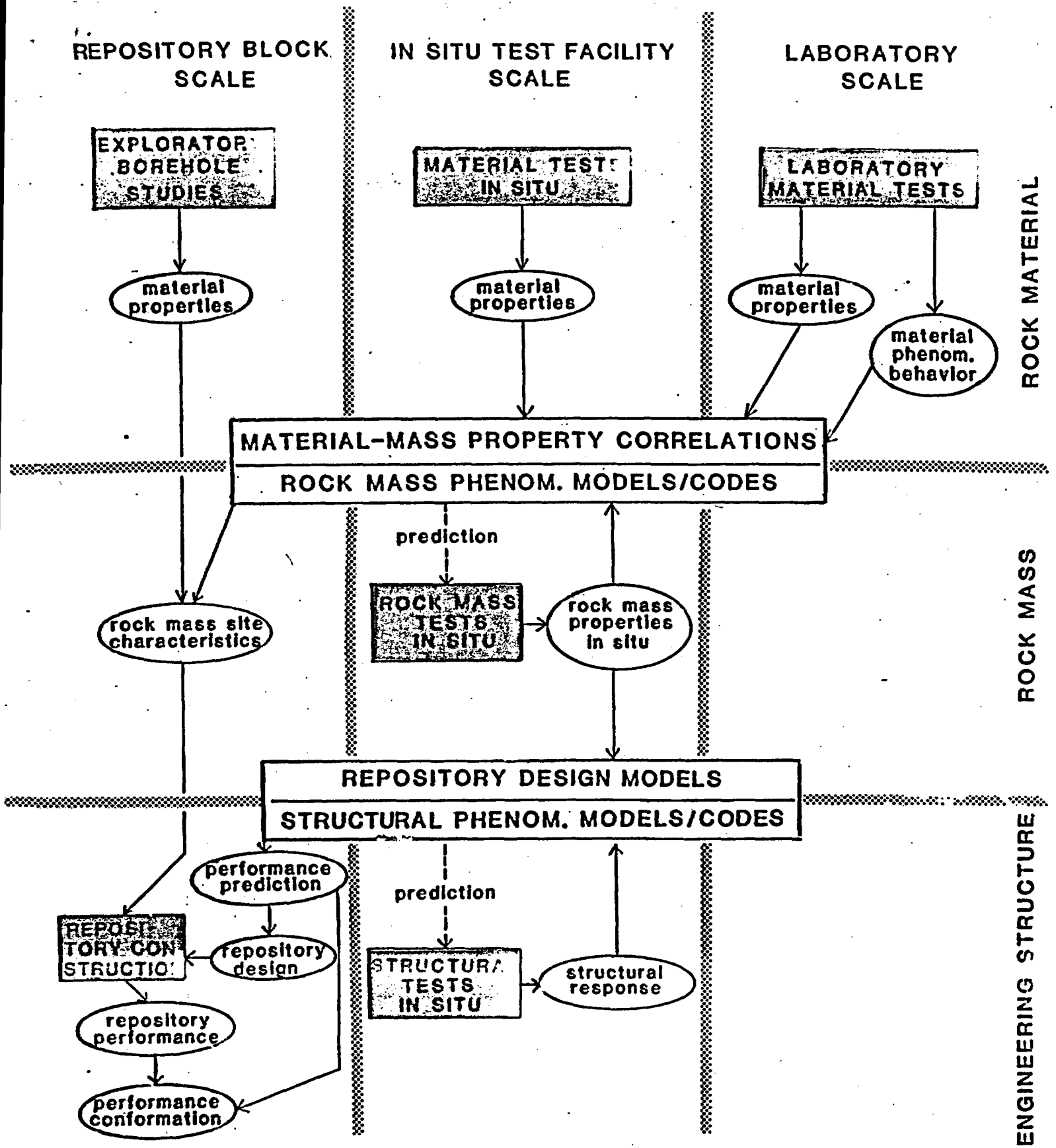
5. Basic mapping scales for underground drifts should be 1 inch map equals 1 foot in drifts.

6. Use of pilot core holes at least 20-30 m ahead of all working faces should be written into the test plan to make predictions of drift conditions and to establish correlation between core logs and face maps.

7. The rationale for the orientation of the underground facility should be provided in the test plan.

8. Generic or interpretative terms in mapping of discontinuities in drift mapping should not be used as a substitute for accurate description.

9. NRC believes that for correlation, the same suite of logs should be run in all holes in the underground facility, vertical or horizontal. NRC is concerned about the adequacy of using only single point resistivity tests in the exploratory shaft boreholes.



TEST LOGIC DIAGRAM

(NRC/LPG)

ROLE OF SITE CHARACTERIZATION STUDIES IN REPOSITORY PERFORMANCE ASSESSMENT

ATT. 5

ATTACHMENT-6

THMC QUESTIONS

1. What is the overall DOE strategy on addressing the THMC coupling issue?

2. What are DOE's plans to develop an integrated THMC interaction model?

3. For what specific problems are there simplified approaches that can be used to bound the interaction effects?

4. How will the models of individual phenomena be combined?

5. How does DOE plan to evaluate the importance of the THMC interaction effects and the consequences on long term waste isolation and containment?

6. What in situ test plan is being proposed by DOE specifically to address the THMC interactions?

7. How much of the in situ testing will be completed during the prelicense application stage and how much of it will continue after license application?

8. Will the physical and chemical phenomenological processes of THMC interaction be adequately understood before LA/permanent closure?

9. Is site-specific testing needed and if so what kind of site-specific data are required and with what reliability should they be measured and for how long?

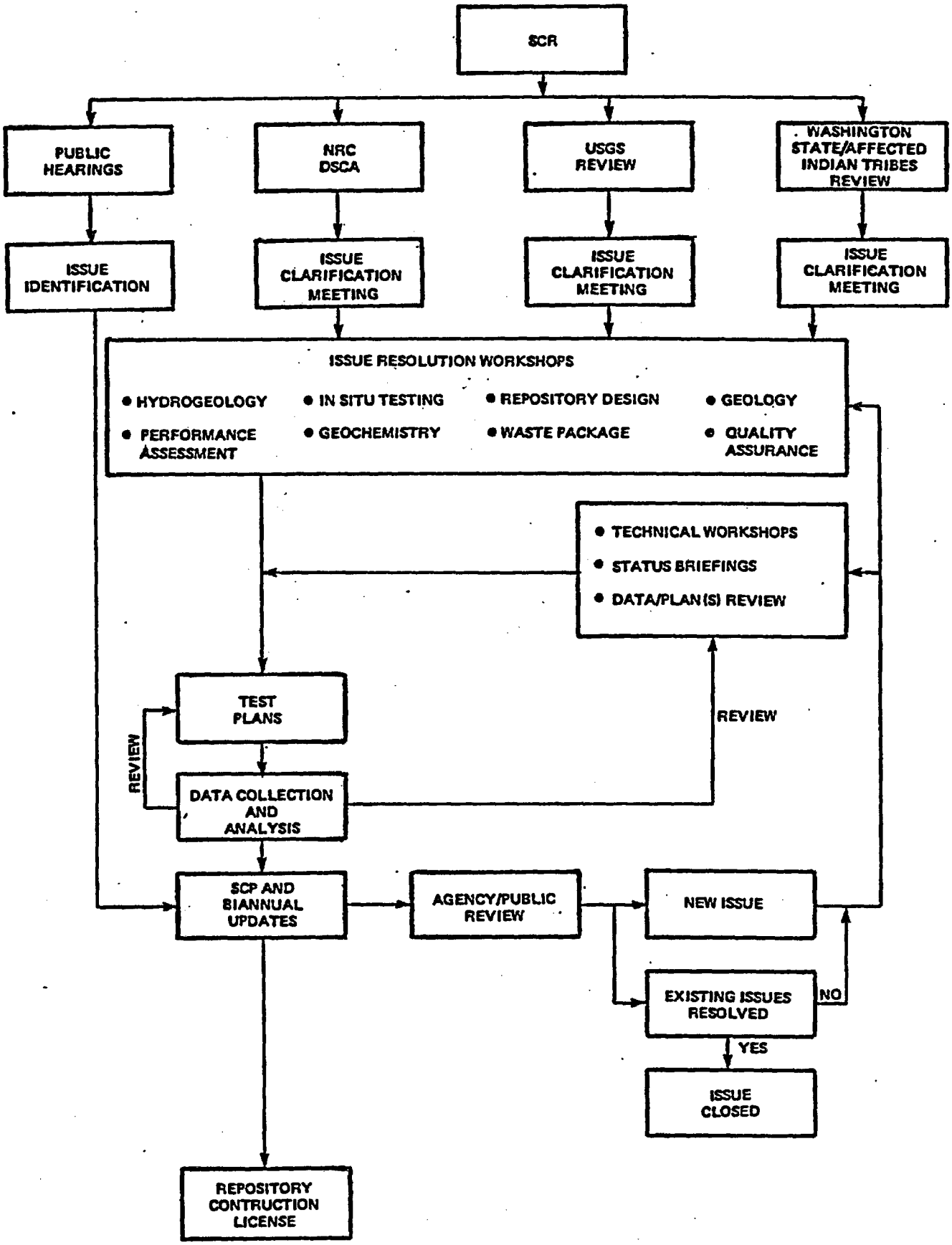
10. Could the repository design circumvent foreseeable uncertainties that might result from a lack of thorough understanding of the THMC coupling phenomena?

DOE/NRC MEETING ON

EXPLORATORY SHAFT AND UNDERGROUND TESTING

NOVEMBER 1983

SITE CHARACTERIZATION ISSUE RESOLUTION/CLOSURE PROCEDURE



JA831107-36

AGENDA
DOE/NRC MEETING ON
EXPLORATORY SHAFT AND UNDERGROUND TESTING
BASALT WASTE ISOLATION PROJECT

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DOE Consultants: J. Bartlett, Z. Bieniawski, P. Dominico, W. Hustrulid, J. Smith

NRC: J. Greeves, M. Logsdon, R. Natarata, R. Wright

NRC Consultants: E. Corp, J. Daemen, L. Gonano, E. Hollop, L. Mundell, V. Rajaram, M. Serbousek, K. Wahi, R. Williams

Rockwell: R. J. Bielefeld, H. B. Dietz, R. E. Gephart, K. A. Hadley, J. F. Marron W. M. McCabe, T. M. Wintczak

USGS: G. Dinwiddie, P. Stevens

Other Attendees:

State of Washington: D. Provost, D. Stevens

Yakima Indian Nation: J. Hovis, L. Lehman

Confederated Tribes of the Umatilla Indian Reservation: M. Farrow, R. Lothrop, E. Patawa, C. Wilson

CHO, NPO, NNWSI: To be determined

NOVEMBER 29, 1983

8:00 DOE Introduction

8:15 DOE Information

8:30 BWIP overview of Exploratory Shaft In Situ Test Plan:

- o Preparation process and schedule, including current status and revisions planned to accommodate comments received from the Overview Committee and others.
- o Methodology for resolving open, workshop, and "agreed" items resulting from BWIP's dispositioning of NRC comments on underground testing raised in the Draft Site Characterization Analysis.
- o Test Plan's responsiveness to open, workshop, and "agreed" items.

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1:00 Discuss NRC's preliminary comments on draft In Situ Test Plan

- o Geology
- o Hydrology

NOVEMBER 30, 1983

8:00 Continue discussion of NRC's preliminary comments

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- o Hydrology

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- o Constructibility

DECEMBER 1, 1983

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3:30	NRC present disagreements and agreements
4:00	BWIP/NRC develop consensus on disagreements and agreements

DECEMBER 2, 1983

8:00	Technical wrap-up
10:00	Management wrap-up
11:00	Preparation of meeting notes

PROGRAMMATIC

H. B. DIETZ

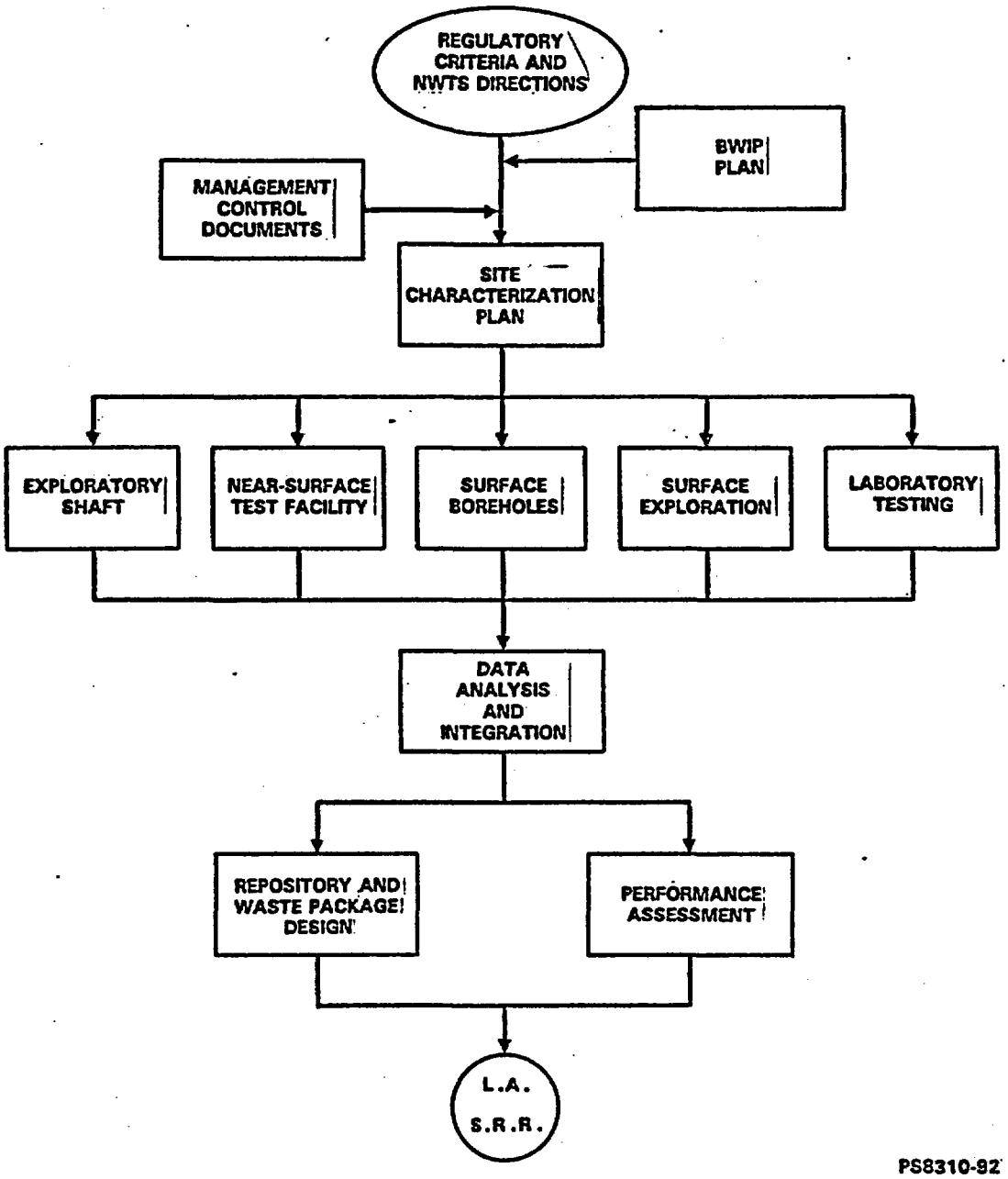


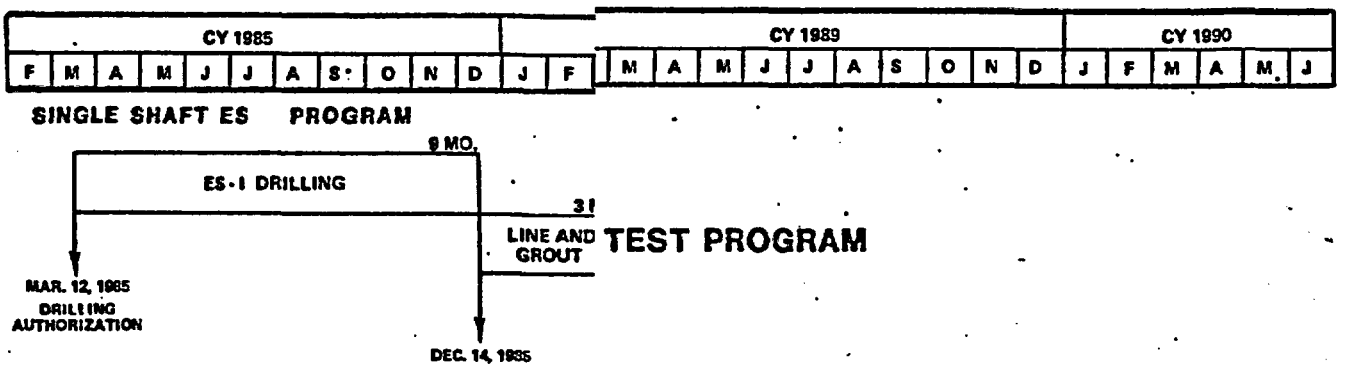
FIGURE 1-2. Logic for Site Characterization.

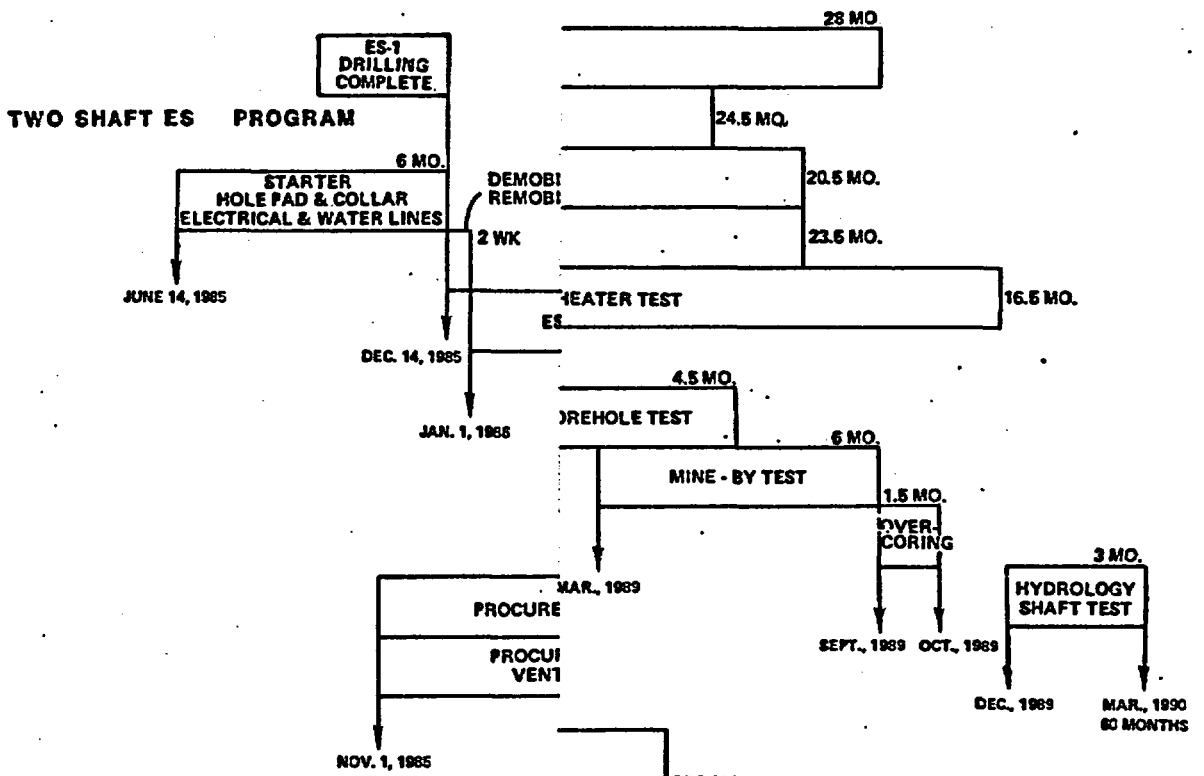
DEVELOPMENT OF EXPLORATORY SHAFT TEST PLAN

- MAY 1980 ISSUE — BASIS FOR PRECONCEPTUAL DESIGN OF ES
- AUGUST 1981 ISSUE — BASIS FOR DETAILED DESIGN OF ES PHASE I
- NOVEMBER 1983 DRAFT — FULLY DEVELOPED TEST PROGRAM FOR ES PHASE I AND PHASE II

FEATURES OF PRESENT TEST PLAN DRAFT

- TRACEABLE TO DRAFT 10 CFR 60 CRITERIA
- INCLUDES IN SITU TEST PROGRAM (ES PHASE I AND ES PHASE II) FOR SITE CHARACTERIZATION
- MOST BWIP OVERVIEW COMMITTEE COMMENTS INCORPORATED
- BASIS FOR START OF CONCEPTUAL DESIGN FOR ES PHASE II AND TEST INSTALLATIONS
- BASIS FOR PREPARATION OF SCP CHAPTER ON IN SITU TESTING





BWIP ES TEST PROGRAM (1 SHAFT VERSUS 2 SHAFTS)

- ONE SHAFT LIMITS UNDERGROUND OCCUPANCY TO 1: EMERGENCY EGRESS REQUIREMENT TO EVACUATE A 30 MINUTES. A SECOND SHAFT WILL ELIMINATE THIS DUE TO REVERSIBLE VENTILATION SYSTEM AND MUL EGRESS.
- GEOMECHANICS TESTS AND MINE-BY TESTS CAN BE ST SOONER BECAUSE OF GREATER NUMBER OF WORKER
- SHAFT HYDROLOGY TEST COMPLETELY BLOCKS THE PERMITS THIS TEST TO BE DONE IN PARALLEL WITH C 3 MONTHS.
- SECOND SHAFT PROVIDES FOR IMPROVED VENTILATI INCREASED PRODUCTIVITY.
- THE POTENTIAL FOR TESTING IN ADDITIONAL PORTH HORIZONS CAN BE ACCOMMODATED WITH MINOR SCH MO. SECOND SHAFT IS INSTALLED.
- IF ADDITIONAL IN SITU TESTS ARE REQUIRED, THE ON A SHORTER SCHEDULE.

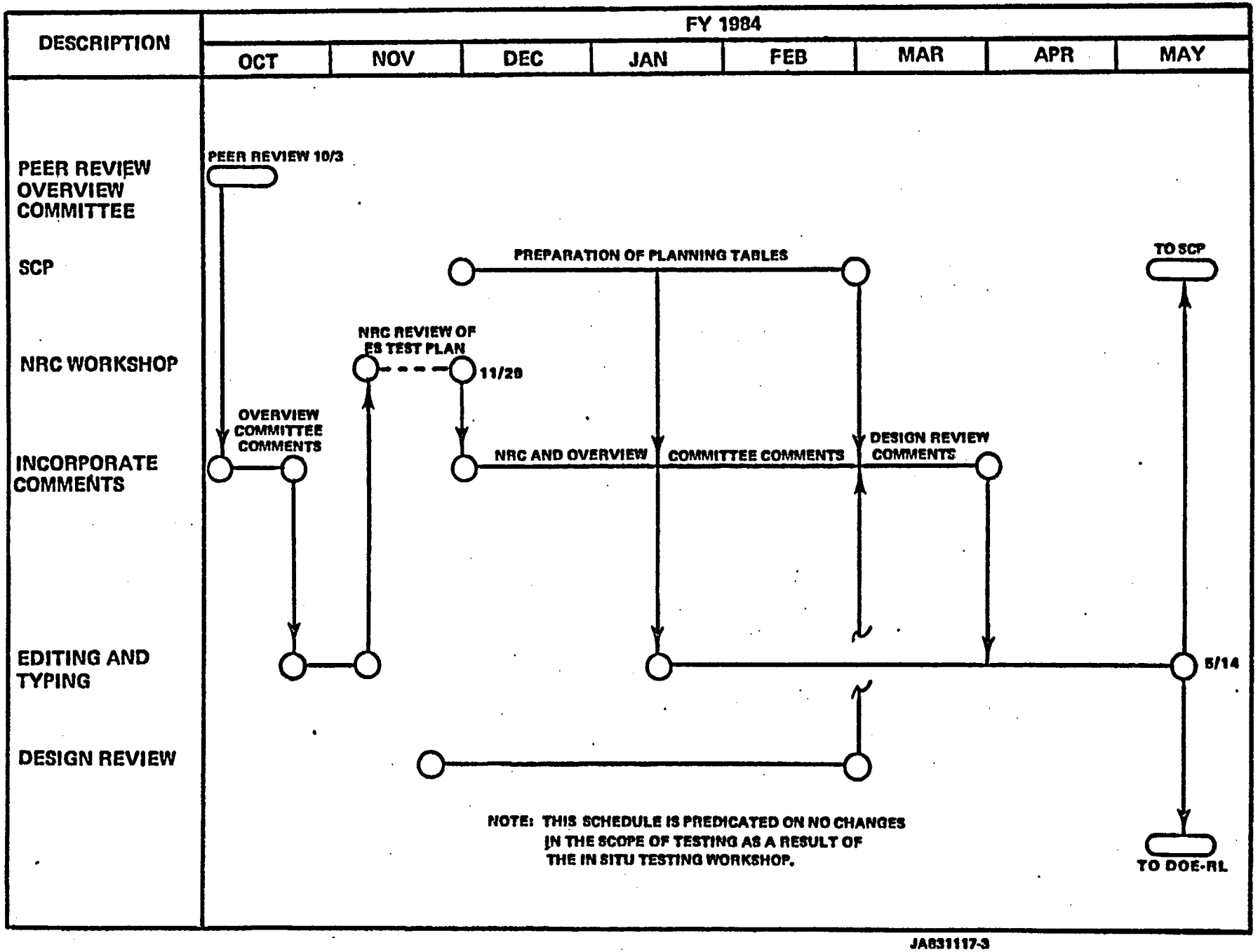
APPROVAL

H. B. Dietz

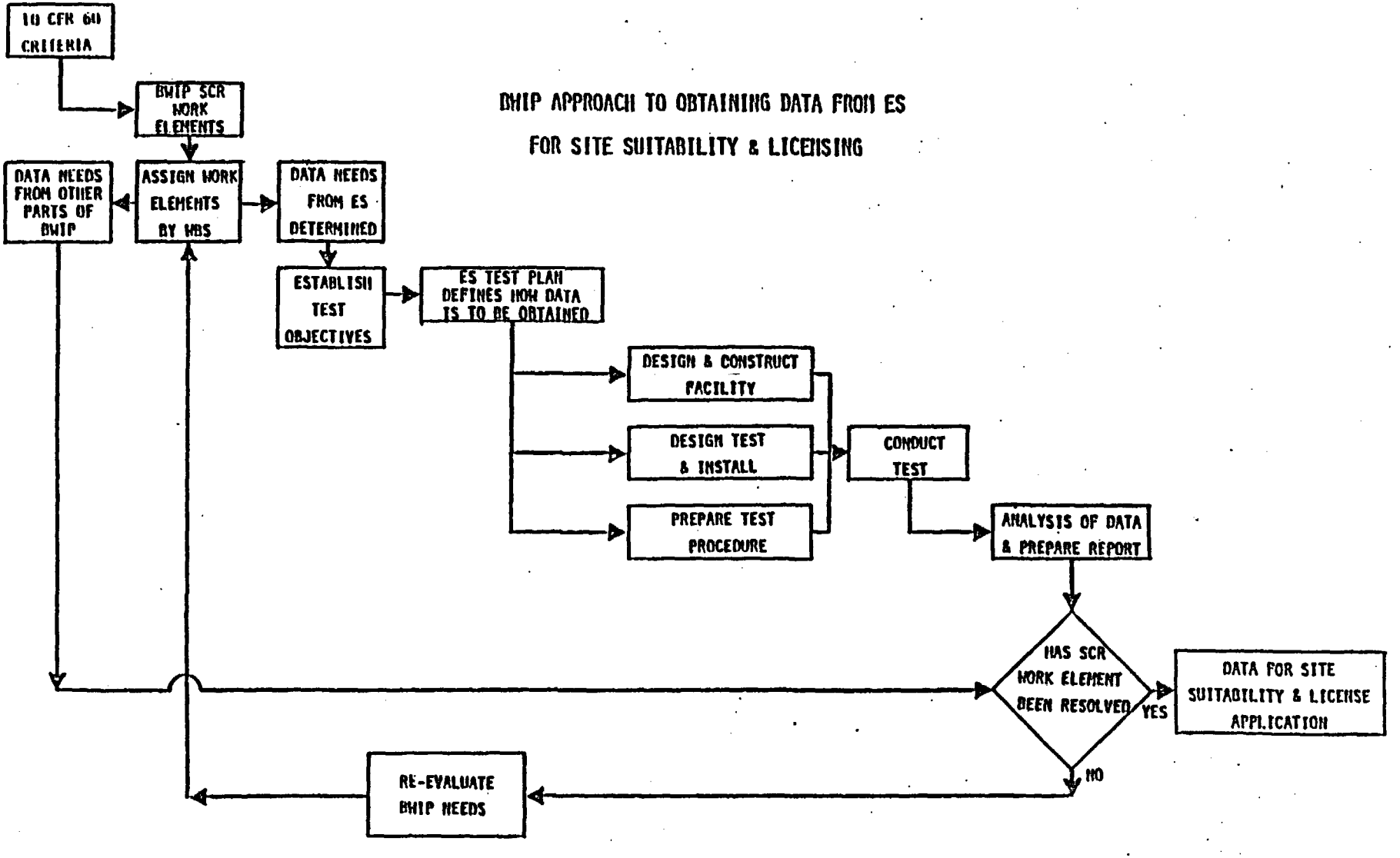
H.B. DIETZ
PROGRAM MANAGER

NOV. 17, 1983
DATE

JA830828-6


DESCRIPTION
FY 1984
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
PEER REVIEW OVERVIEW COMMITTEE
SCP
NRC WORKSHOP
INCORPORATE COMMENTS
EDITING AND TYPING
DESIGN REVIEW
PEER REVIEW 10/3
PREPARATION OF PLANNING TABLES
TO SCP
NRC REVIEW OF ES TEST PLAN
11/29
OVERVIEW COMMITTEE COMMENTS
NRC AND OVERVIEW
COMMITTEE COMMENTS
DESIGN REVIEW COMMENTS
5/14
NOTE: THIS SCHEDULE IS PREDICATED ON NO CHANGES IN THE SCOPE OF TESTING AS A RESULT OF THE IN SITU TESTING WORKSHOP.
TO DOE-RL

JA831117-3


BWIP APPROACH TO OBTAINING DATA FROM ES
FOR SITE SUITABILITY & LICENSING
10 CFR 60 CRITERIA
BWIP SCR WORK ELEMENTS
DATA NEEDS FROM OTHER PARTS OF BWIP
ASSIGN WORK ELEMENTS BY WBS
DATA NEEDS FROM ES DETERMINED
ESTABLISH TEST OBJECTIVES
ES TEST PLAN DEFINES HOW DATA IS TO BE OBTAINED
DESIGN & CONSTRUCT FACILITY
DESIGN TEST & INSTALL
PREPARE TEST PROCEDURE
CONDUCT TEST
ANALYSIS OF DATA & PREPARE REPORT
HAS SCR WORK ELEMENT BEEN RESOLVED
YES
NO
DATA FOR SITE SUITABILITY & LICENSE APPLICATION
RE-EVALUATE BWIP NEEDS

TECHNICAL OBJECTIVES / PLANNED TESTS	PHASE I						PHASE II				REFERENCE SECTION	
	I-1 PRINCIPAL BOREHOLE	I-2 SHAFT CONSTRUCTIBILITY	I-3 SHAFT LINER SEALING	I-4 SHAFT STATION GEOHYDROLOGY	I-5 SHAFT STATION GEOMECHANICS	I-6 SHAFT STATION CONSTRUCTIBILITY	II-1 GEOLOGIC CHARACTERIZATION	II-2 HYDROLOGIC CHARACTERIZATION	II-3 GEOMECHANICS CHARACTERIZATION	II-4 UNDERGROUND CONSTRUCTIBILITY	EXPLORATORY SHAFT TEST PROGRAM VOLUME I	PRELIMINARY TEST DESCRIPTION VOLUME II
GEOLOGIC CHARACTERIZATION												
PRINCIPAL BOREHOLE TESTS	●										5.1.4	APPENDIX A
BOREHOLE TESTS				●	○		●	○	○		5.2.1	2.2.1
FACILITY TESTS					○	●	●	○	○	●	5.2.1	2.2.2
HYDROLOGIC CHARACTERIZATION												
PRINCIPAL BOREHOLE TESTS	●										5.1.4	APPENDIX A
BOREHOLE HYDROLOGY TESTS				●				●	○		5.2.2	3.3
CHAMBER TEST								●			5.2.2	3.4
TRACER TESTS								●			5.2.2	3.5
GEOMECHANICS CHARACTERIZATION												
PRINCIPAL BOREHOLE TESTS	●										5.1.4	APPENDIX A
OPENING DEFORMATION MONITORING					●				●		5.2.3	4.3.2
OPENING SUPPORT MONITORING					●				●		5.2.3	4.3.3
ACOUSTIC EMISSION MONITORING					●				●		5.2.3	4.3.4
BOREHOLE JACKING TEST									●		5.2.3	4.3.5
CROSS HOLE SEISMIC TEST									●		5.2.3	4.3.6
PLATE BEARING TEST									●		5.2.3	4.3.7
LARGE FLAT JACK TEST									●		5.2.3	4.3.8
ROOM-SCALE ENLARGEMENT									●		5.2.3	4.3.9
CANISTER HOLE DRILLING TEST									●			4.3.10
HEATER TEST									●			4.3.11
SMALL FLAT JACK TEST									●		5.2.3	4.3.12
OVERCORING TEST					●				●		5.2.3	4.3.13
HYDRAULIC FRACTURING TEST									●		5.2.3	4.3.14
CONSTRUCTIBILITY REPORTING		●	●			●				●	5.3	5.0

PS8310-77

LEGEND

● PRIMARY DATA ○ SUPPORTING DATA

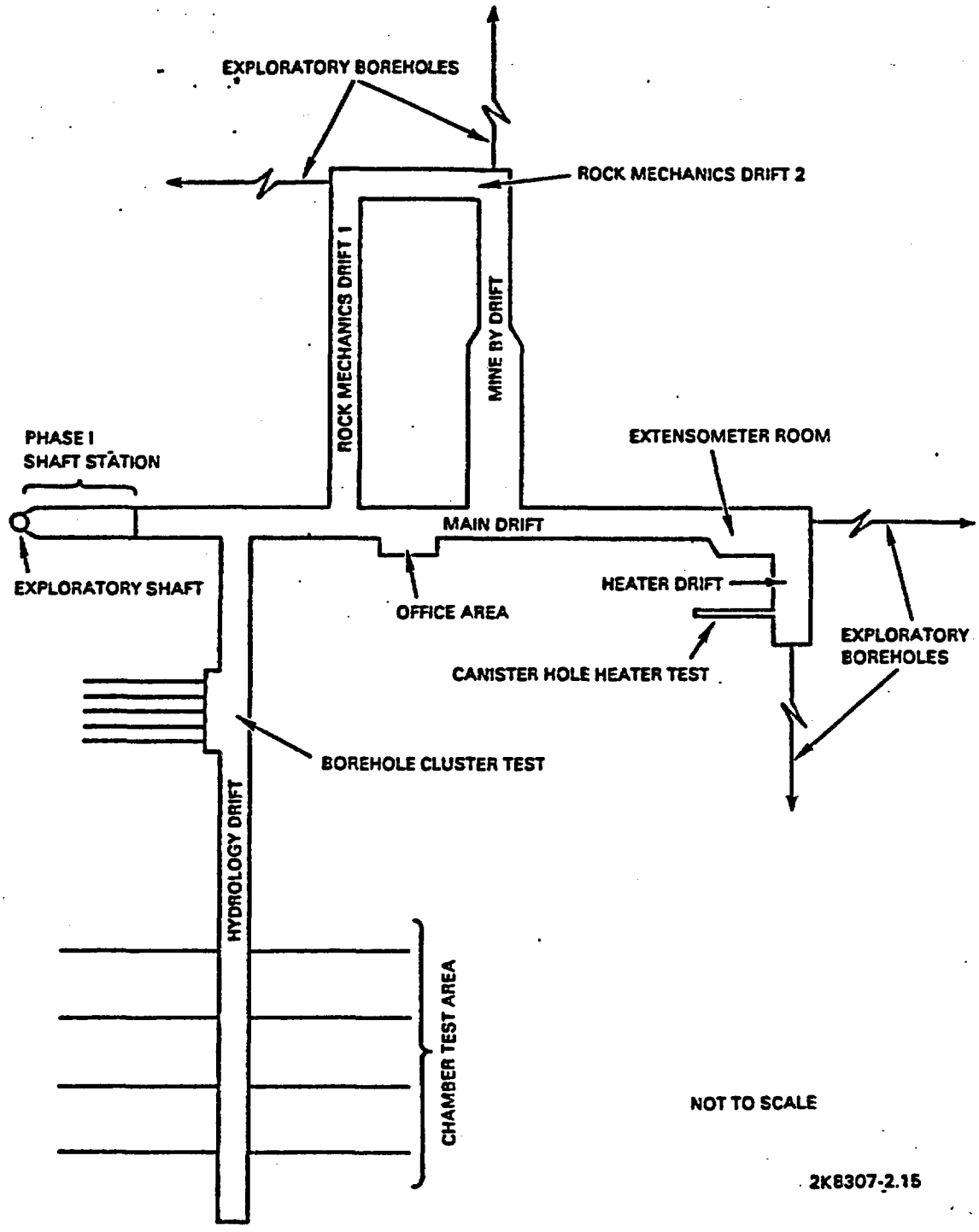


FIGURE 2-3. Exploratory Shaft-Phase II Conceptual Arrangement.

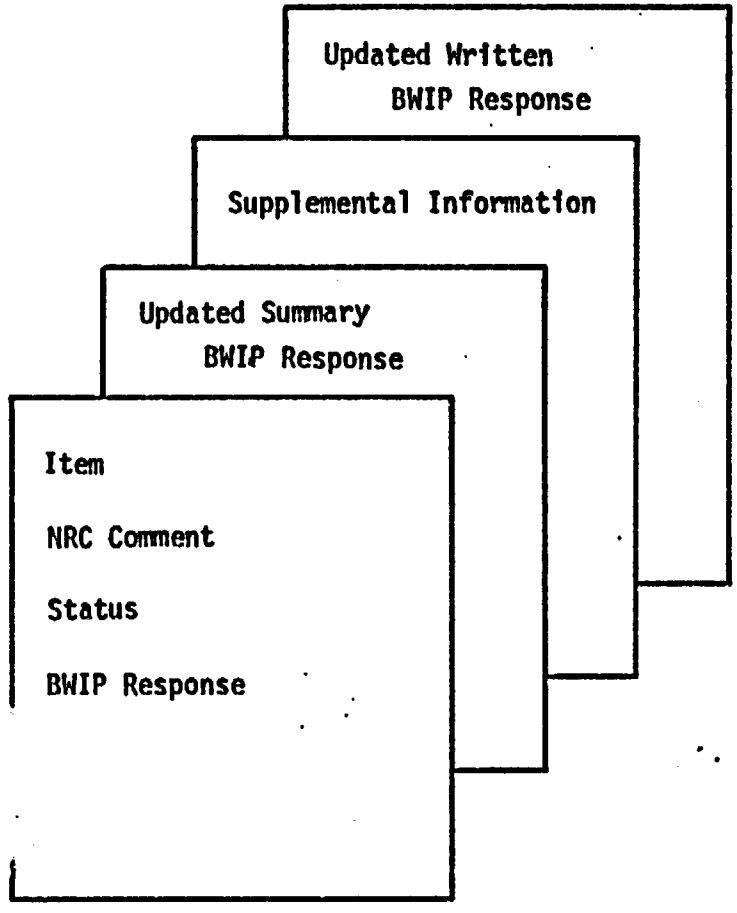
SUMMARY OF DRAFT
SITE CHARACTERIZATION ANALYSIS DISPOSITIONS

AREA OF INTEREST	MAJOR OPEN ITEMS	TOTAL NRC COMMENTS
HYDROGEOLOGY	3	132
PERFORMANCE ASSESSMENT	7	163
GEOLOGY	4	83 (3)
WASTE PACKAGE/GEOCHEMISTRY	14	268
REPOSITORY DESIGN	4 (1)	122 (13)
QUALITY ASSURANCE	2	41
SITE PROGRAM	-	74 (12)
TOTAL	34 (1)	883 (28)

DOE/NRC WORKSHOPS

TOPIC	TENTATIVE DATES (WEEK OF)
UNDERGROUND TESTING	11/28/83
GEOCHEMISTRY/HYDROLOGY	1/09/84
REPOSITORY DESIGN	1/23/84
WASTE PACKAGE	2/27/84
GEOLOGY	3/12/84

WORKSHOP APPROACH
TO DISCUSSION OF DSCA ITEM



ES TEST PROGRAM

DSCA ITEMS

PROGRAMMATIC	H. B. DIETZ
GEOLOGY	T. M. WINTCZAK
HYDROLOGY	R. E. GEPHART
GEOMECHANICS	W. M. MC CABE
CONSTRUCTIBILITY	R. J. BIELEFELD

ITEM REFERENCE: SECTION 6.3.1, PAGE 6-4, PARAGRAPH 3

NRC COMMENT

WHAT IS THE STATUS OF ROCK MECHANICS STUDY (R.1.10.A) AS AN INPUT TO TEST PLAN:

- TESTS REQUIRED
- MEASUREMENTS NECESSARY
- TEST ACCURACY
- EFFECT OF PARAMETERS ON DESIGN

STATUS

AGREED

BWIP RESPONSE

WORKSHOP IS REQUIRED TO DISCUSS TEST PLAN

ITEM REFERENCE: Section 6.3.1, page 6-4, paragraph 3

Work Element R.1.10.A identifies the need for measuring certain rock mechanics parameters and the rigor with which to measure them. The outcome of this study should provide valuable input to the in situ test plan. Answers to many questions--such as what tests should be performed, how many measurements should be made, how accurate should the tests be, and how the various measured parameters will affect the design--will become available when this work element is completed. Therefore, it is logical to give this work element a high priority and use the results of the study as a basis for the exploratory shaft test plan. However, the status of this work element (SCR Chapter 14) shows that the work is yet to be performed, but the schedule (SCR Chapter 17) shows that rock mechanics planning (activity 9) is complete as of FY80, and mine model codes development (activity 13) is almost complete. If the work is complete, as shown in the schedule, the results of the study should be made available to the NRC staff at an early date. If the work is yet to be performed, as portrayed in the status report, then the NRC staff recommends that the work be completed at an early date.

NRC COMMENT: "What tests should be performed, how many measurements...how accurate...how...will affect the design?" Key point! i.e., what is the logic behind the test plans? What is the status of this?

STATUS: Agreed

BWIP RESPONSE: A workshop will be held with the NRC to discuss in situ test plans and provide the information now available and approaches that are going to be taken to answer these questions. This is a workshop discussion item. Test plans, with follow up discussion, will provide a portion of this information.

ITEM REFERENCE: SECTION 6.3.1, PAGE 6-4, PARAGRAPH 3

- DRAFT PLAN PROVIDES THE OBJECTIVES FOR THE IN SITU TEST PROGRAM. (SECTION 3)

- PLAN IS TRACEABLE TO DRAFT 10 CFR 60 CRITERIA. (APPENDIX B)

- PLANNED TESTS ARE RELATED TO OBJECTIVES OF TEST PROGRAM. (TABLE 5-1)

- LOGIC BEHIND SELECTION OF TEST TO MEET OBJECTIVES AND OBTAIN DATA TO MEET 10 CFR 60 CRITERIA IS DESCRIBED IN VOLUME II.

ITEM REFERENCE: SECTION 6.3.1, PAGE 6-4, PARAGRAPH 3

BWIP RESPONSE 11/83

THE ES TEST PLAN HAS BEEN PREPARED TO DETAIL THE BWIP IN SITU TEST PROGRAM. THIS PLAN WILL BE USED IN PREPARATION OF THE SITE CHARACTERIZATION PLAN. THE 11/29/83 WORKSHOP WITH THE NRC STAFF PROVIDES AN OPPORTUNITY FOR DISCUSSION OF THE BWIP IN SITU TEST PROGRAM PRIOR TO PREPARATION OF THE BWIP SCP.

STATUS

PENDING -- TO BE CLOSED UPON ISSUE OF THE SCP.

ITEM REFERENCE: SECTION 6.3.5, PAGE 6-10, PARAGRAPH 1-4

NRC COMMENT

TEST PLAN LACKS LOGICAL DEVELOPMENT AND RATIONALE FOR TEST PROGRAM:

- IMPORTANT PARAMETERS
- POTENTIAL VARIABILITY
- MEASURING TECHNIQUES
- REFERENCED TEST PROCEDURES
- DETAILS ON QC/QA

STATUS

AGREED

BWIP RESPONSE

SCP WILL PROVIDE MORE INFORMATION
DISCUSS AT WORKSHOP

ITEM REFERENCE: Section 6.3.5, page 6-10, paragraph 1

The NRC staff's first major comment on the BWIP test plan is that the plan lacks a logic development and rationale for developing the in situ test program. For example, a test plan should identify the important design parameters, classify them according to their relative importance, and document their potential variability and the effect of variability on design. The plan should also identify measuring techniques and their reliability and provide reference to test procedures and details on quality control and quality assurance. Sandia Reports listed at the end of this chapter are good examples of appropriate kind of reference material (Zimmerman and Vollendorf, 1982; Zimmerman, June 1982 and October 1982).

NRC COMMENT:

- Plan lacks a logical development and rational for development.
- Identify important design parameters.
- Document their potential variability.
- Identify measuring technique and reliability.
- Provide references to test procedures and QA. (paraphrased)

STATUS: Agreed

BWIP RESPONSE: More detailed information will be added to Section 10.7.3 of the SCP addressing these items. These items will also be discussed further at a future NRC workshop.

ITEM REFERENCE: SECTION 6.3.5, PAGE 6-10, PARAGRAPH 1-4

- ES PLAN TRACEABLE TO DRAFT 10 CFR 60 CRITERIA.

- THE ES TEST PROGRAM IS ONLY A PORTION OF THE TOTAL BWIP NEEDS FOR SITE CHARACTERIZATION.

- THE SCP WILL DETAIL THE DATA TO BE OBTAINED FOR SITE CHARACTERIZATION FROM ALL SOURCES.

- THE TEST PLAN SPECIFIES DATA NEEDS TO BE OBTAINED FROM IN SITU TESTING FOR SITE SUITABILITY, REPOSITORY DESIGN AND PERFORMANCE ASSESSMENT. (SEE SECTION 6)

- DETAILED TEST PROCEDURES WILL BE DEVELOPED DURING THE TEST DESIGN PHASE.

ITEM REFERENCE: SECTION 6.3.5, PAGE 6-10, PARAGRAPH 1-4

BWIP RESPONSE 11/83

THE BWIP IN SITU TEST PROGRAM IS DEFINED IN THE ES TEST PLAN. THE SCP WILL INCLUDE ALL ASPECTS OF THE BWIP REQUIRED FOR SITE CHARACTERIZATION.

STATUS

PENDING -- TO BE CLOSED FOLLOWING ISSUE OF THE SCP.

ITEM REFERENCE: SECTION 6.3.5, PAGE 6-10, PARAGRAPH 5

NRC COMMENT

LACK OF PLANS FOR:

- FULL SCALE ROOM EXCAVATION
- LARGE SCALE THERMAL-HYDROLOGIC TESTING

STATUS

AGREED (OPEN)

BWIP RESPONSE

NRC CLARIFICATION IS REQUIRED ON:

- TYPE OF TESTING
- METHOD OF ANALYSIS

ITEM REFERENCE: Section 6.3.5, page 6-10, paragraph 5

A major limitation of the in situ test plan is the lack of plans for a full-scale room excavation and large-scale thermal-hydrologic testing in the underground facility during the Phase II testing. Such tests are crucial to demonstrating the stability of openings under complex interactions of heat, water and rock. The NRC staff recommends that DOE consider such tests, because there is no substitute for demonstrating the constructibility and performance of the underground facility. Relationship of an in situ test facility to a deep geologic repository and description of in situ test program as related to the construction of a repository have been studied by NRC contractors. The results of such studies (NUREG/CR-2959, NUREG/CR-2547 and NUREG/CR-3065) have been used by the NRC staff in the review of the BWIP in situ test plan. The NRC staff has also discussed with DOE the importance of at-depth testing during the NRC/DOE workshop (see Wright, 1982).

NRC COMMENT: Major limitation, lack of plans for (1) full-scale room excavation and (2) large-scale thermal-hydrologic testing in underground facility during Phase II. (paraphrased)

STATUS: Agreed (Open)

BWIP RESPONSE: This topic will be included at a future NRC workshop. Clarification of the type of testing proposed and the method of analysis is needed.

ITEM REFERENCE: SECTION 6.3.5, PAGE 6-10, PARAGRAPH 5

- A FULL SCALE ROOM EXCAVATION IS INCLUDED IN ES TEST PLAN. (SEE SECTION 5.2.3)

- THE NEED FOR A COUPLED THERMAL/HYDROLOGIC/GEOCHEMICAL TEST WILL BE ADDRESSED ON A NWTS PROGRAM WIDE BASIS.

ITEM REFERENCE: SECTION 6.3.5, PAGE 6-10, PARAGRAPH 5

BWIP RESPONSE 11/83:

THE ES TEST PROGRAM NOW INCLUDES A FULL-SCALE ROOM EXCAVATION (MINE BY). THE NEED FOR A COUPLED THERMAL/HYDROLOGIC/GEOCHEMICAL TEST WILL BE ADDRESSED ON A NWTS PROGRAM WIDE BASIS.

STATUS: OPEN

ITEM REFERENCE: SECTION 17.2.6, PAGE 17.2-24, PARAGRAPH 1

NRC COMMENT

DEFINE SITE TO ANALYZE DATA FROM ES-II

STATUS

AGREED (OPEN)

BWIP RESPONSE

NRC CLARIFICATION IS REQUIRED

ITEM REFERENCE: Section 17.2.6, page 17.2-24, paragraph 1

The test data obtained in the Exploratory Shaft - Phase I will play an important role in the detailed design of the various in situ tests to be conducted in Phase II. It is not possible to determine the exact tests and the detailed test designs until access to the candidate repository horizons is available through the exploratory shaft. A series of observations during construction of the Exploratory Shaft - Phase II, in situ stress measurements, laboratory tests of rocks removed from the exploratory shaft construction area, and horizontal exploratory coring will be utilized to allow a final geotechnical assessment of the site's suitability and to provide repository design information prior to submittal of the License Application.

NRC COMMENT: "A series of observations during construction of the Exploratory Shaft - Phase II, ..."/10 -- "Criteria for final geotechnical information prior to submittal of the license assessment of application. The site should be defined to properly analyze the data from ES-II."

STATUS: Agreed (Open)

BWIP RESPONSE: The BWIP would like clarification from the NRC on this comment.

ITEM REFERENCE: SECTION 17.2.6 PAGE 17.2.24, PARAGRAPH 1

BWIP RESPONSE 11/83

THE BWIP WOULD LIKE CLARIFICATION FROM THE NRC ON THIS COMMENT.

STATUS

OPEN

ITEM REFERENCE: SECTION 17.2.8, PAGE 17.2-29, PARAGRAPH 3

NRC COMMENT

ADDRESS SEALING, BACKFILL PERFORMANCE, AND RETRIEVEABILITY IN TEST PROGRAM

STATUS

OPEN

BWIP RESPONSE

- NEED IS NOT EVIDENT
- TESTS CAN BE PERFORMED ELSEWHERE
- REQUESTED TESTS ARE FOR DESIGN CONFIRMATION, NOT SITE CHARACTERIZATION
- WILL DISCUSS AT WORKSHOP

ITEM REFERENCE: Section 17.2.8, page 17.2-29, paragraph 3

TEST PROGRAM OBJECTIVE 1 (PHASE II)

Provide geotechnical information to enable characterization of a volume of the candidate repository horizon selected for breakout to allow a decision on the suitability of this site for a repository.

Work Elements

S.1.1.A Determine the thickness and continuity of the candidate repository horizons within the reference repository location.

S.1.2.A Determine the dip, strike, fold wavelength, and amplitude of the candidate repository horizons within the reference repository location.

S.1.3.A Determine what deformational features are likely to intersect the candidate repository horizons within the reference repository location.

S.1.4.A Determine the primary internal structure of the candidate repository horizons within the reference repository location.

S.1.6.A Determine the mineralogic and petrographic characteristics of the candidate repository horizons including the composition, texture, and abundance of both primary and secondary phases; apply data as appropriate the predict fracture distribution in Work Element S.1.5.A.

R.1.2.A Evaluate the effect of the underground construction sequence on the stability of the openings.

R.1.4.A Determine the magnitude and distribution of excavation-induced stresses for single and multiple openings.

R.1.8.A Determine the spatial variation of in situ stresses in the region of the repository.

NRC COMMENT: "Provide geotechnical information to enable characterization of a volume ... to allow a decision on the suitability of this site for repository."/18 -- "Sealing, backfill performance, and retrievability are not addressed in this testing program."

STATUS: Open

BWIP RESPONSE: The need for testing sealing, backfill performance, and retrievability in the ES-Phase II is not yet evident. With the possible exception of sealing, this testing, to the extent that testing is warranted, could be performed in other facilities (e.g., NSTF). Regardless of where such testing is done, it would be for design confirmation purposes rather than site characterization purposes, and thus does not necessarily support a site suitability decision. A workshop will be held to discuss this item with the NRC.

ITEM REFERENCE: SECTION 17.2.8, PAGE 17.2-29, PARAGRAPH 3

- TESTING OF SEALING, BACKFILL PERFORMANCE AND RETRIEVEABILITY IS FOR DESIGN CONFIRMATION RATHER THAN SITE CHARACTERIZATION.

- THIS ISSUE TO BE ADDRESSED ON A NWTS PROGRAM WIDE BASIS AND IS NOT PART OF THIS WORKSHOP.

ITEM REFERENCE: SECTION 17.2.8, PAGE 17.2-29, PARAGRAPH 3

BWIP RESPONSE 11/83

THE PURPOSE OF SEALING, BACKFILL PERFORMANCE AND RETRIEVEABILITY TESTING IS FOR DESIGN CONFIRMATION RATHER THAN SITE CHARACTERIZATION. TESTING, IF NEEDED, WOULD BE CONDUCTED FOLLOWING LICENSE APPLICATION. THE NEED FOR THIS TESTING WILL BE ADDRESSED ON A NWTS PROGRAM WIDE BASIS.

STATUS

OPEN

GEOLOGY

T. M. WINTCZAK

ITEM REFERENCE: SECTION 4.4.1, PAGE 4-7, PARAGRAPH 3

NRC COMMENT

RETRIEVE ORIENTED CORES

STATUS

AGREED

BWIP RESPONSE

- MAGNETIC ORIENTATION DEVICES ARE UNRELIABLE
- FRACTURE ORIENTATION DATA WILL BE OBTAINED IN PHASE II
- ALTERNATE METHODS ARE UNDER INVESTIGATION

ITEM REFERENCE: Section 4.4.1, page 4-7, paragraph 3

The SCR summarizes the details of plans and programs for the two unresolved issues discussed in Section 4.3 in the form of generalized work elements: "These specific work elements were further analyzed to identify in detail the data required and the analysis needed to complete each work element..." (page 13.6-1). The NRC staff is concerned that the work elements do not always provide the details of the data and analyses required to complete each work element. Therefore, it is difficult to make an independent assessment of the likelihood of success of the work plans. For example, additional boreholes in the RRL will be logged in detail to determine the primary internal structure of the candidate repository horizon (SCR, page 13.3-4). Yet the SCR states: "(These) data will provide only limited information regarding local variations in the thickness of intraflow structure..." (page 13.3-11). DOE should include plans to retrieve oriented core to provide definitive data on the orientation of fractures in the candidate repository horizons. Also, DOE should consider the drilling of angle holes to characterize vertical fracturing.

NRC COMMENT: "The DOE should include plans to retrieve oriented cores to provide definitive data on the orientation of fractures in the candidate repository horizons."

STATUS: Agreed

BWIP RESPONSE: Orientation of core in the Umtanum flow has been attempted in previous coring operations. However, the only available orientation devices for small diameter core depend on magnetic compasses which are notably unreliable in highly magnetic rocks such as basalt. Data on fracture orientation will also be obtained in the Exploratory Shaft, Phase II. Alternative methods for providing definitive data on the orientation of fractures are being investigated.

ITEM REFERENCE: SECTION 4.4.1, PAGE 4-7, PARAGRAPH 3

BWIP RESPONSE 11/83

THE ES TEST PLAN (VOLUME II, SECTION 2.2.1) PROVIDES FOR ORIENTED CORE FROM ALL INSTRUMENT BOREHOLES AND A METHOD FOR ORIENTING SELECTED PORTIONS OF THE EXPLORATORY BOREHOLES. ADDITIONAL DATA ON FRACTURE ORIENTATIONS WILL BE PROVIDED BY THE DISCONTINUITY MAPPING (VOLUME II, SECTION 2.2.2) THAT WILL TAKE PLACE IN THE UNDERGROUND FACILITY.

STATUS

PENDING -- TO BE CLOSED UPON ISSUANCE OF THE SCP.

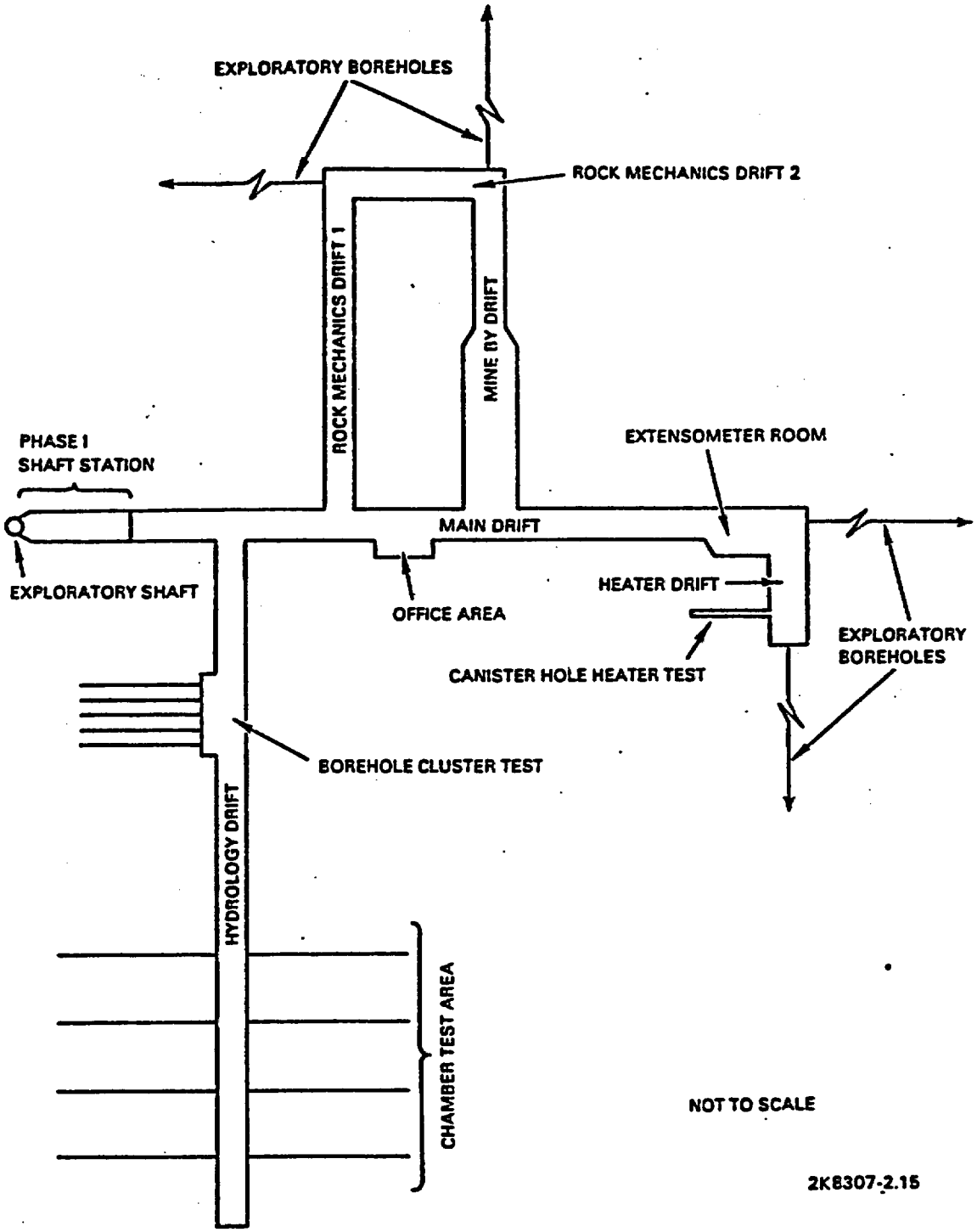


FIGURE 2-3. Exploratory Shaft-Phase II Conceptual Arrangement.

ITEM REFERENCE: SECTION 17.2.2, PAGE 17.2-4, PARAGRAPH 3

NRC COMMENT

DEFINE THE TESTS TO BE PERFORMED IN SITE CHARACTERIZATION BOREHOLES (RRL-6 AND 14) AND PRINCIPAL BOREHOLE (RRL-2) AND DATA EXTRAPOLATION TO RRL

STATUS

AGREED

BWIP RESPONSE

TEST PLAN WILL EXPLAIN HOW ES TESTING RELATES TO OTHER SITE CHARACTERIZATION TESTING

ITEM REFERENCE: Section 17.2.2, page 17.2-4, paragraph 3

Selection of the candidate horizon for breakout will be based on the borehole data obtained from the site characterization boreholes (RRL-6 and RRL-14) as well as the principal borehole (RRL-2). These will be compiled in a report on geologic, hydrologic, rock mechanics, geochemical, and economic aspects of the candidate repository horizons. This information will be analyzed by means of a formal decision analysis technique. The various characteristics of the candidate repository horizons will be judged either favorable or unfavorable, the characteristics will be weighted according to their relative importance, and the horizons will be ranked to select the best horizon for breakout. This study is scheduled for completion by May 1983.

NRC COMMENT: "Selection of the candidate horizon for breakout ... as well as the principal borehole (RRL-2)."/9 -- "The tests that will be performed in these holes and the manner in which the data from these holes will be used in extrapolating ES-II data base to the RRL should be defined!"

STATUS: Agreed

BWIP RESPONSE: The Exploratory Shaft will be used to enhance characterization of the RRL. The Test Plan will describe this process, explaining the relationship to other site characterization testing.

ITEM REFERENCE: SECTION 17.2.2, PAGE 17.2-4, PARAGRAPH 3

BWIP RESPONSE 11/83

THE ES TESTING IS ONLY ONE OF SEVERAL DATA SOURCES THAT WILL BE IDENTIFIED IN THE SCP. ADDITIONAL DATA WILL COME FROM NEAR SURFACE TESTING, SURFACE BOREHOLES, SURFACE EXPLORATION, AND LABORATORY TESTING. SECTION 1.2, VOLUME I OF THE ES TEST PLAN DISCUSSES THE RELATIONSHIP OF THE ES DATA TO OTHER SITE CHARACTERIZATION DATA.

STATUS

PENDING -- TO BE CLOSED UPON ISSUANCE OF THE SCP.

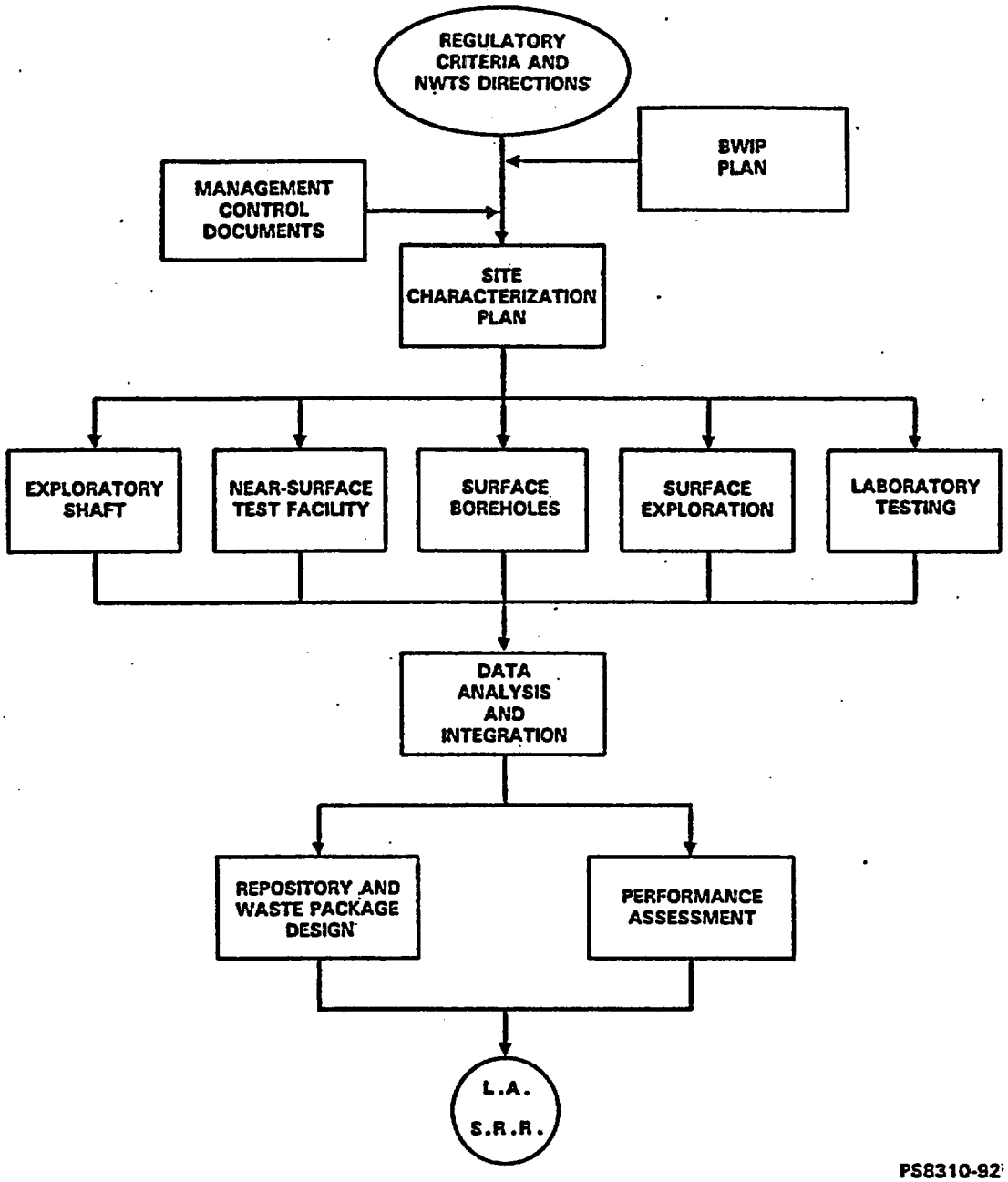


FIGURE 1-2. Logic for Site Characterization.

ITEM REFERENCE: SECTION 4.4.2, PAGE 4-8, PARAGRAPH 4

NRC COMMENT

USE STATE-OF-THE-ART GEOPHYSICAL TECHNIQUES

STATUS

AGREED

BWIP RESPONSE

TECHNIQUES WILL BE INVESTIGATED AND DOCUMENTED IN ES TEST PLAN AND REFERENCED IN SCP

ITEM REFERENCE: Section 4.4.2, page 4-8, paragraph 4

Given the potential variation in flow characteristics, the NRC staff is concerned that the proposed boring program will not adequately define the subsurface geology so that engineering fixes will effectively resolve geologic problems adversely impacting inflow of groundwater into drifts and stability of openings. The use of "state-of-the-art" geophysical techniques in the test facility should be considered as a means of identifying geologic anomalies in the repository host rock.

NRC COMMENT: "The use of "state-of-the-art" geophysical techniques...in the repository host rock."

STATUS: Agreed

BWIP RESPONSE: State-of-the-art geophysical techniques are being identified for Exploratory Shaft investigations. A phased approach will be used to insure that the applicability of all the more routine methods are thoroughly investigated. All of the geophysical techniques used or planned will be documented in the ES test plan and referenced in the SCP.

ITEM REFERENCE: SECTION 4.4.2, PAGE 4-8, PARAGRAPH 4

BWIP RESPONSE 11/83

THE GEOPHYSICAL TECHNIQUES FOR ANOMALY DETECTION, TO BE USED IN THE ES, HAVE NOT YET BEEN DETERMINED AND ARE THEREFORE NOT INCLUDED IN THE ES TEST PLAN.

A CONTRACT HAS BEEN PLACED WITH WOODWARD CLYDE CONSULTANTS TO PREPARE A TEST PLAN FOR THE INVESTIGATION OF ANOMALY DETECTION BY ACOUSTAL METHODS AND PASSIVE SURVEILLANCE BY SIESMIC METHODS. A REQUEST FOR PROPOSAL IS ALSO BEING PREPARED FOR TESTING OF EXISTING INSTRUMENTATION AND DEVELOPMENT OF THIS INSTRUMENTATION FOR USE IN THE UNDERGROUND FACILITY.

STATUS

PENDING -- TO BE CLOSED UPON ISSUANCE OF THE SCP.

ITEM REFERENCE: SECTION 4.4.2, PAGE 4-8, PARAGRAPH 4

NRC COMMENT

PRESENT RATIONALE FOR ADEQUACY OF BOREHOLE INVESTIGATIONS TO DEFINE SUBSURFACE GEOLOGY VARIATION AND EFFECT ON GROUNDWATER FLOW AND STABILITY OF OPENINGS

STATUS

AGREED

BWIP RESPONSE

RATIONAL WILL BE PROVIDED IN TEST PLAN AND REFERENCED SCP

ITEM REFERENCE: Section 4.4.2, page 4-8, paragraph 4

Given the potential variation in flow characteristics, the NRC staff is concerned that the proposed boring program will not adequately define the subsurface geology so that engineering fixes will effectively resolve geologic problems adversely impacting inflow of groundwater into drifts and stability of openings. The use of "state-of-the-art" geophysical techniques in the test facility should be considered as a means of identifying geologic anomalies in the repository host rock. In determining the extent to which there should be additional borehole investigations, from the surface and from the underground facility, a rationale must be presented on the adequacy of these investigations to resolve the uncertainties discussed above.

NRC COMMENT:

"In determining the extent to which there should be additional borehole investigations, from the surface and from the underground facility, a rationale must be presented on the adequacy of these investigations to resolve the uncertainties discussed above."

STATUS: Agreed

BWIP RESPONSE:

The fundamental bases for determining the adequacy of knowledge of the site are geostatistics and performance assessment evaluations. Additional borehole investigations will be based on the need to reduce uncertainty as prescribed by geostatistics and performance assessment allocations. The requested rationale will be included in the drilling and testing plan, the ES test plan, and will be referenced in the SCP.

ITEM REFERENCE: SECTION 4.4.2, PAGE 4-8, PARAGRAPH 4

BWIP RESPONSE 11/83

THE APPLICABILITY OF GEOSTATISTICS TO THE GEOLOGIC DATA BASE IS BEING INVESTIGATED BY PACIFIC NORTHWEST LABORATORY. ONCE THIS IS COMPLETE, THE APPLICABLE GEOSTATISTICS WILL BE USED TO DETERMINE THE UNCERTAINTY IN THE DATA BASE. THIS INFORMATION WILL THEN BE USED TO DETERMINE WHETHER ADDITIONAL BOREHOLE INVESTIGATIONS ARE REQUIRED TO REDUCE THE UNCERTAINTY. THE RATIONALE FOR BOREHOLES IN THE ES IS DISCUSSED IN SECTION 2.2.1, VOLUME I OF THE ES TEST PLAN.

STATUS

PENDING -- TO BE CLOSED UPON ISSUANCE OF THE SCP.

HYDROLOGY

R. E. GEPHART

ITEM REFERENCE: SECTION 17.2-3, PAGE 17.2-14, PARAGRAPH 1

NRC COMMENT

DESCRIBE TYPE OF TESTS AND ANALYSES TO BE USED IN HORIZONTAL AND INCLINED TEST HOLES FROM THE SHAFT

STATUS

AGREED

BWIP RESPONSE

ES TEST PLAN WILL PRESENT INFORMATION

ITEM REFERENCE: Section 17.2.3, page 17.2-14, paragraph 1

17.2.3.4 Preliminary Hydrologic Isolation Assessment (Test Program Objective 4 (Phase I)). Drilling of horizontal test holes and inclined test holes through portholes in the shaft will be performed above, below, and in the horizon selected for breakout. The locations of the test boreholes is diagrammatically shown in Figure 17-5. The lengths of these boreholes are dependent on the geometry of the flow being tested and has not been determined. Lengths are not expected to exceed 75 meters (250 feet). The basic hydrologic tests will consist of hydraulic head, hydraulic conductivity, and sampling for water chemistry. The key data measurements are given in Table 17-5.

NRC COMMENT: Lines 1-10, "Drilling of horizontal ... given in Table 17.5."/3 -- "What type of tests and analyses will be used on what intervals, etc...?"

STATUS: Agreed

BWIP RESPONSE: Additional information on interval testing and analyses will be presented in the Exploratory Shaft Test Plan.

ITEM REFERENCE: SECTION 17.2.3, PAGE 17.2-4, PARAGRAPH 1

BWIP RESPONSE 11/83

SECTION 3.3, VOLUME II OF THE ES TEST PLAN DETAILS THE SPECIFIC LOCATIONS AND DESIGNS OF ALL PORTHOLES. IN ADDITION, TEST PRIORITIES, METHODOLOGIES AND ANALYSES ARE EXPLAINED.

STATUS

PENDING -- TO BE CLOSED UPON ISSUANCE OF THE ES TEST PLAN.

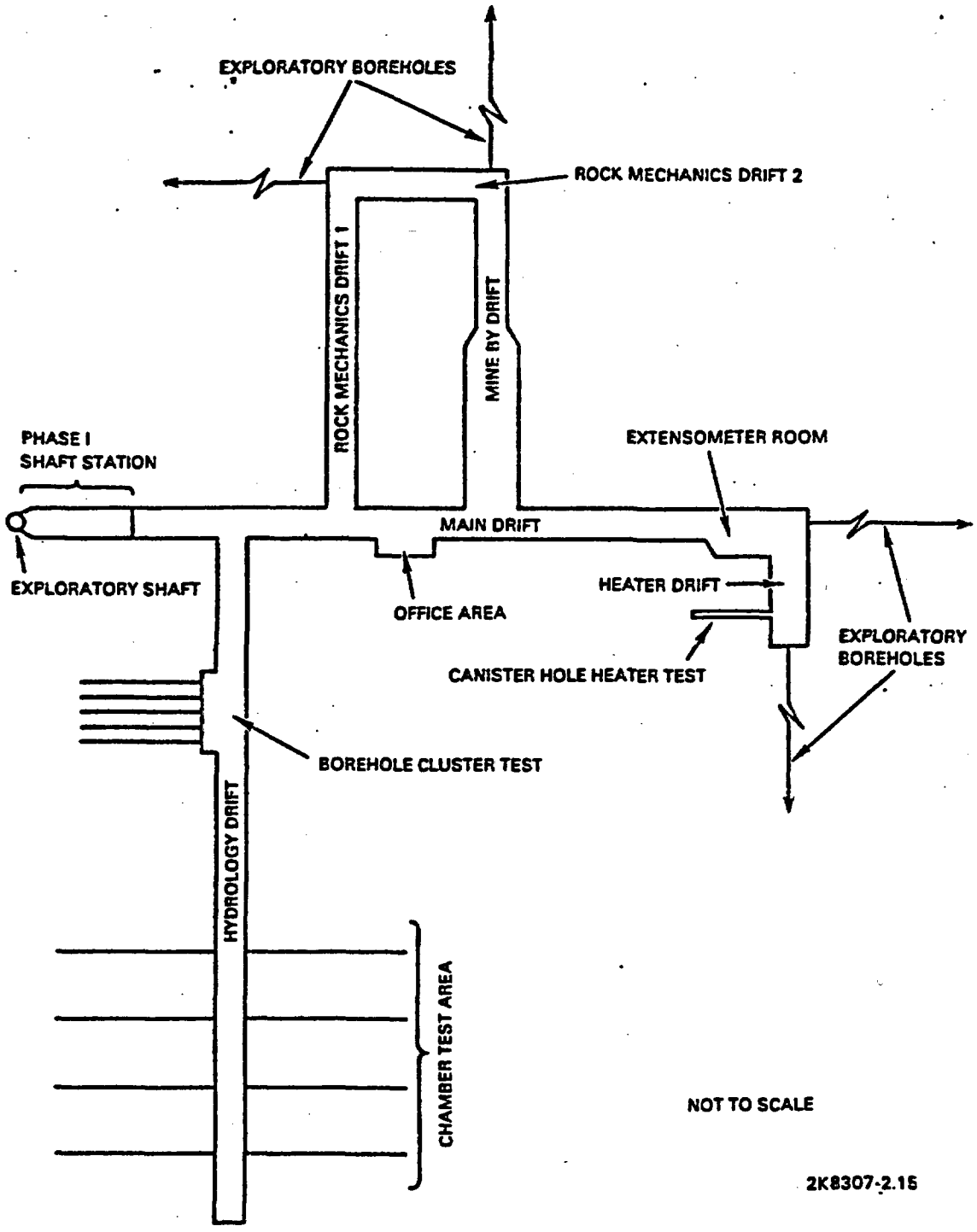


FIGURE 2-3. Exploratory Shaft-Phase II Conceptual Arrangement.

TABLE 3-8. Porthole Drilling and Testing Priority.

	Priority		Stratigraphic Horizons	Portholes Committed
Candidate horizon	1 (must before Phase II)		Candidate horizon[a] flow interior	13 (at 7 depths)
	2	confirmatory data from Phase II	Candidate horizon flow top/bottom and intraflow zones	13 (at 7 depths)
Other Grande Ronde Flows	3		Other Grande Ronde flow interiors	54 (at 20 depths)
	4		Other Grande Ronde flow tops and intraflow zones	26 (at 14 depths)
Saddle Mountains and Wanapum Flows	5	contingency data	Saddle Mountains and Wanapum flow interiors	5 (at 5 depths)
	6		Saddle Mountains and Wanapum flow tops and interbeds	11 (at 11 depths)

(a) The Cohassett flow is the preferred candidate repository horizon.

TABLE 3-5. Borehole Specifics.

Boreholes	Number Proposed for Testing	Diameter	Length	Purpose
Shaft boreholes*				
• flow top and interbeds	47	48 mm (1.89 in.)	Varies between 12 and 39.6 m (40 and 130 ft)	Single and possibly multiple borehole tests
• flow interiors	73	48 mm (1.89 in.)	18.3 (60 ft)	Single and possibly multiple borehole tests
Chamber boreholes	17	76 mm (2.98 in.)	23 m (75 ft)	Single hole tests; piezometers for monitoring chamber test
Cluster boreholes	9	76 mm (2.98 in.)	23 m (75 ft)	Single and multiple hole tests
Long exploratory boreholes	4	76 mm (2.98 in.)	330 m (1,000 ft)	Single hole tests

* Testing priority dependent on schedule and data needs.

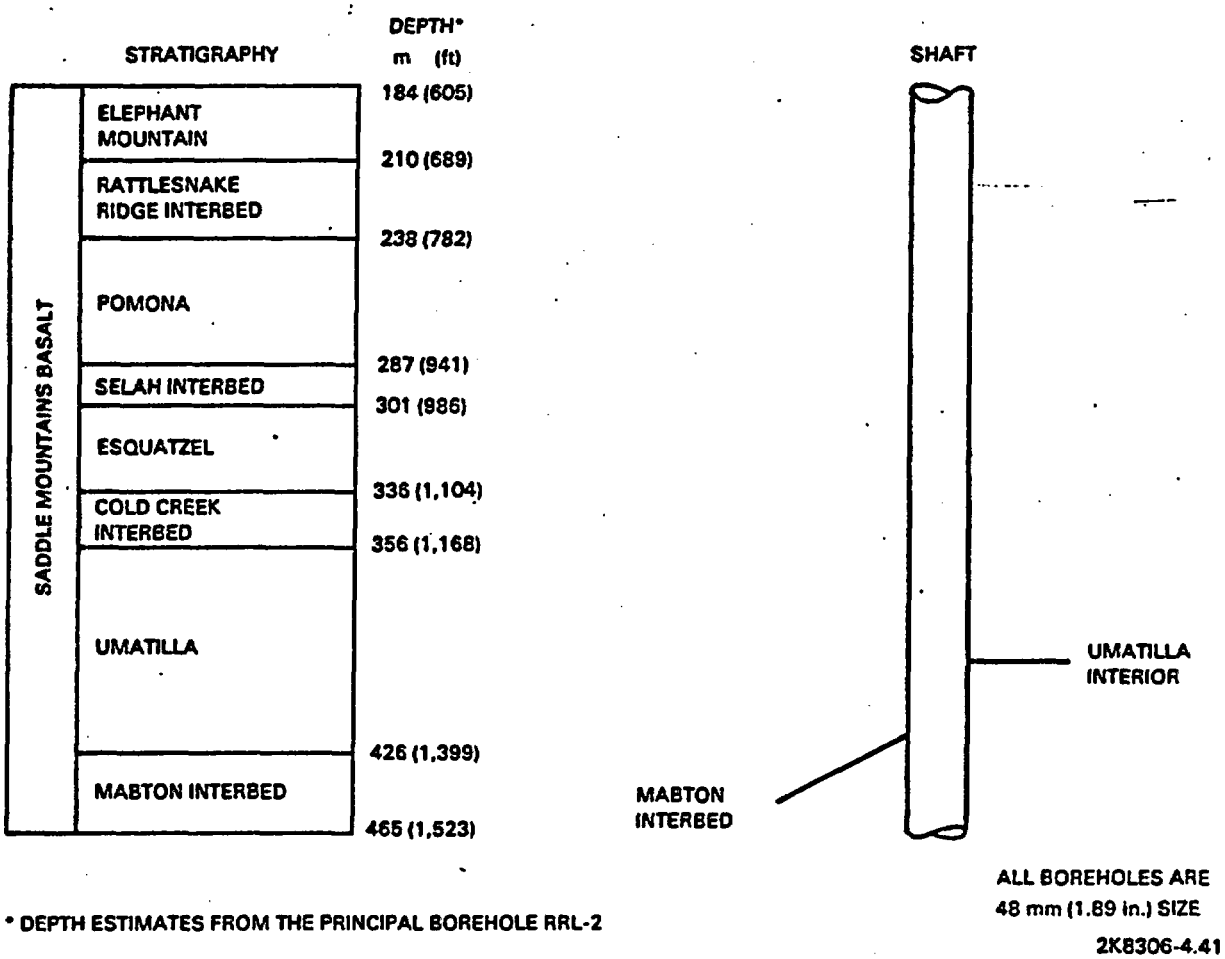


FIGURE 3-5. Boreholes Available for Hydrologic Testing Drilled from the Exploratory Shaft Within the Saddle Mountains Basalt.

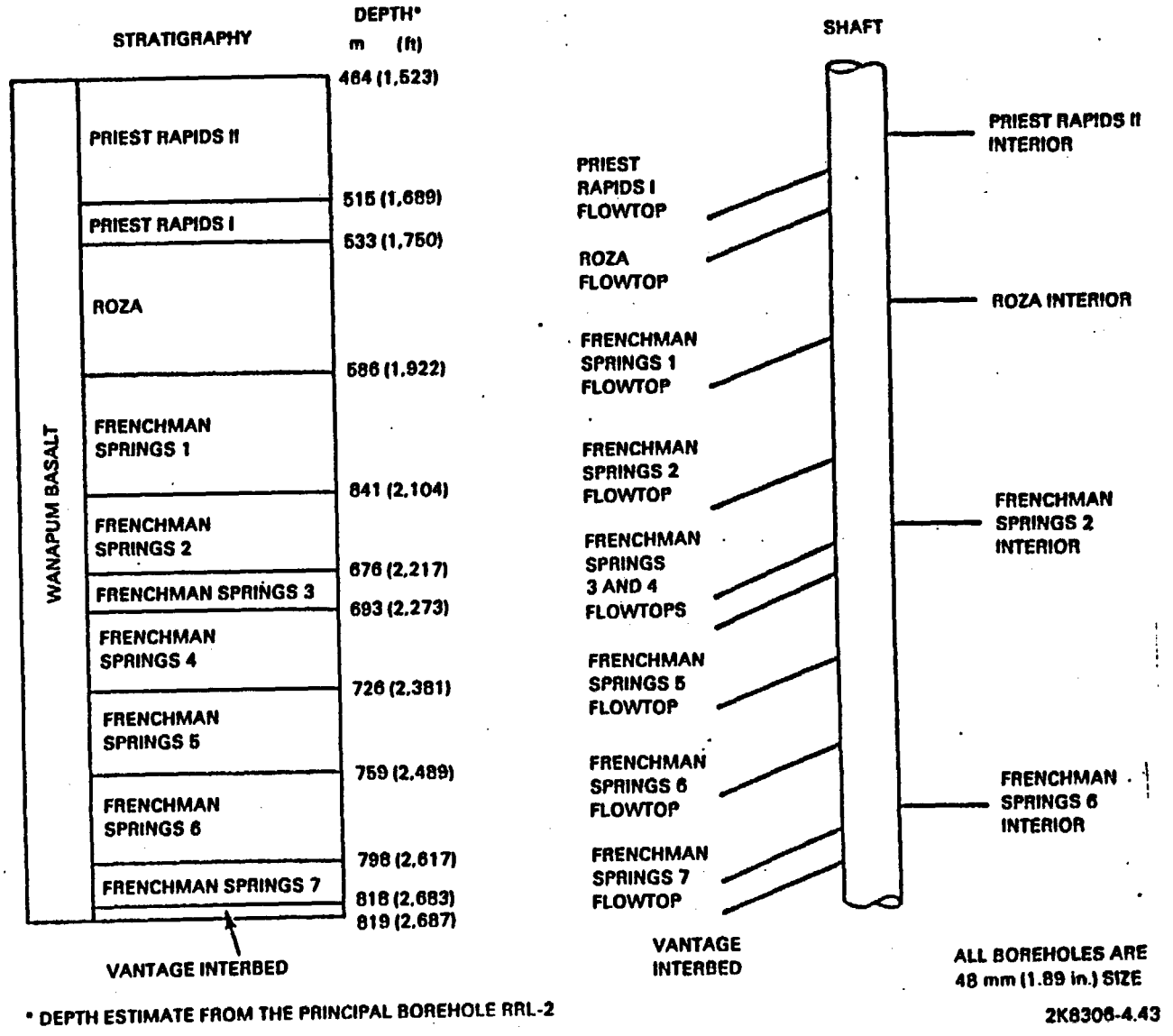


FIGURE 3-6. Boreholes Available for Hydrologic Testing Drilled from the Exploratory Shaft Within the Wanapum Basalt.

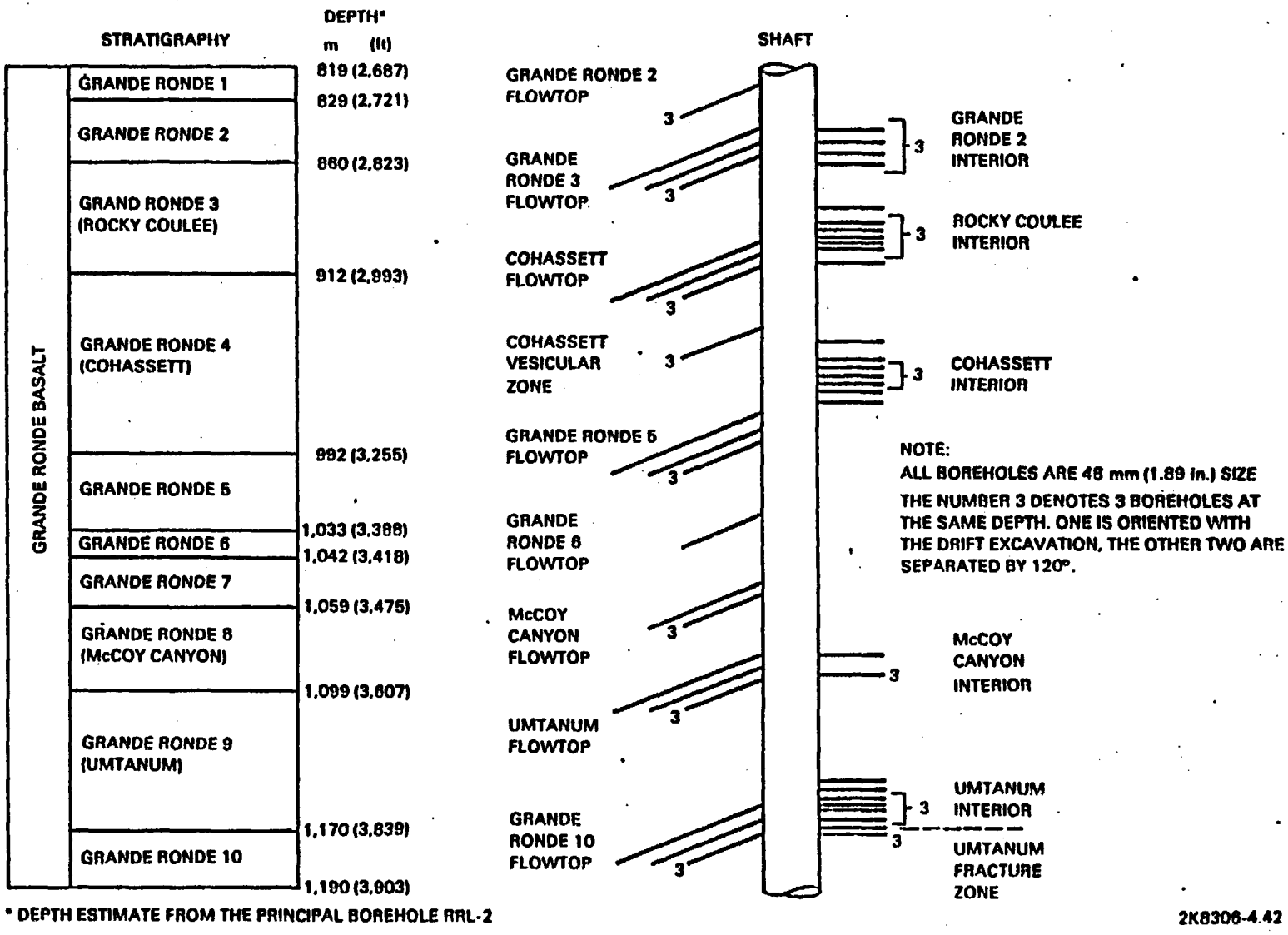


FIGURE 3-7. Boreholes Available for Hydrologic Testing Drilled from the Exploratory Shaft Within the Grande Ronde Basalt.

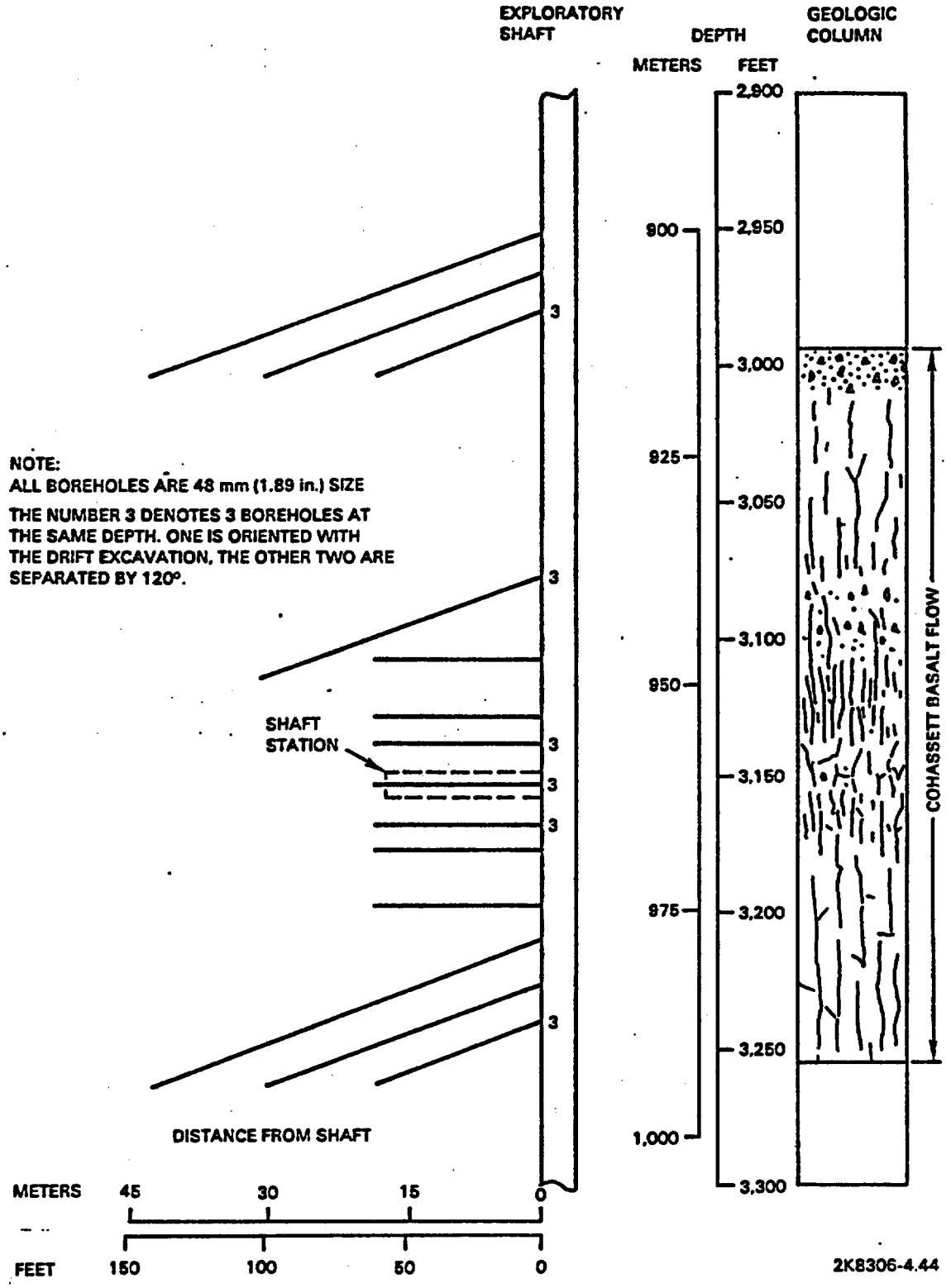


FIGURE 3-3. Proposed Boreholes into the Preferred Candidate Repository Horizon Drilled from the Exploratory Shaft.

TABLE 3-1. Hydrologic Information Obtained from the Exploratory Shaft.

Data Source	Hydraulic Conductivity and Storativity	Effective Porosity, Dispersivity and Distribution Coefficient	Hydraulic Heads[a]	Groundwater Samples
Exploratory Shaft Boreholes	Low Transmissive Zones ● constant head injection* ● pulse ● cross hole tests High Transmissive Zones ● constant drawdown* ● constant discharge*	Low Transmissive Zones[b] ● radial flow* ● dilution methods High Transmissive Zones ● reciculation* ● convergent flow* ● dilution methods	Low Transmissive Zones ● heads monitored in response to testing High Transmissive Zones ● heads monitored in response to testing ● absolute and differential heads monitored	Low Transmissive Zones ● not planned High Transmissive Zones ● sampling planned
Long Exploratory Boreholes Cored into Cohassett from drift	● constant head injection* ● pulse	not planned	● heads monitored in response to testing	not planned
Boreholes Cored from Chamber room into Cohassett flow interior (holes are piezometers for chamber test)	● constant head injection* ● pulse ● cross hole test	not planned though tracer tests are possible after chamber test is completed.	heads monitored in response to chamber test	not planned
Multiple Borehole Cluster Test in Cohassett flow interior	● constant head injection* ● pulse ● cross hole test*	● radial flow* ● dilution methods	heads monitored in response to cluster testing	not planned
Chamber Test (large scale hydrology test) in Cohassett flow interior	● direct measurement of water inflow[c]* ● ventilation system*	not planned though borehole to chamber tracer tests are possible following chamber test.	chamber will be maintained at atmospheric pressure. Head measurement not appropriate.	water seeps on chamber walls can be sampled

* Primary test planned.

(a) Natural, undisturbed heads may be strongly influenced by shaft construction.

(b) Tracer testing from shaft is possible but not of high priority (primary tracer testing in high transmissive zones will be in surface boreholes).

(c) Water measurement technique will be function of inflow rate.

TABLE 3-10. Generalized Procedure for Constant Head Injection Test.

Test conducted in a flow interior (zone of low hydraulic conductivity)
Achieve hydrostatic head or expected value (inject water if necessary)
Allow pressurized system to equilibrate or obtain pressure trend. Equilibration time may require a few days; trend developed over few hours.
Set up injection manifold system on porthole
Inject inert gas into water filled tank of manifold to achieve pressure steps, e.g., 40, 80, 120 lb/in.^{2} above lithostatic pressure. Monitor injection rate.
Maintain each pressure step for 1-1/2 to 2 hr or until a steady-state flow is achieved
Conduct three to four pressure steps
Record discharge versus time and pressure versus time data
Reduce data and apply transient solution after Jacob and Lohman (1952) and for steady-state solution after Zeigler (1976)
Time commitment for completion of tests $\leq$ 6-12 hr

TABLE 3-2. Hydrologic Test Scheduling Estimates.

Borehole Locations				Number of Boreholes: High Priority[a]	Number of Boreholes: Confirmatory[b]	Number of Boreholes: Contingency[c]	Number of Tests (# of holes) (# of tests per hole) = total number of tests: High Priority[a]	Number of Tests: Confirmatory[b]	Number of Tests: Contingency[c]	Test Time (# of tests) (test time) = total test time: High Priority[a]	Test Time: Confirmatory[b]	Test Time: Contingency[c]
Shaft Boreholes	single hole test	Low transmissive zones (interiors)		13(P1)*	54(P3)	5(P5)	13(3)* = 39 tests	54(3) = 162 tests	5(3) = 15 tests	39(1)* = 39 days	162(1) = 162 days	15(1) = 15 days
		High transmissive zones (flow tops/interbeds)		13(P2)	26(P4)	11(P6)	13(3) = 39 tests	26(3) = 78 tests	11(3) = 33 tests	(39)(1) = 39 days	78(1) = 78 days	33(1) = 33 days
	multiple hole test	Cross hole tests	GR#2 interior		4 holes per set	4 holes per set		1 test in one set	2 tests in two sets		1(180) = 180 days	2(180) = 360 days
			Rocky Coulee interior		6 holes per set	6 holes per set		1 test in one set	2 tests in two sets		1(180) = 180 days	2(180) = 360 days
			McCoy Canyon interior		2 holes per set	2 holes per set		1 test in one set	2 tests in two sets		1(180) = 180 days	2(180) = 360 days
			Umtanum interior		6 holes per set	6 holes per set		1 test in one set	2 tests in two sets		1(180) = 180 days	2(180) = 360 days
		Tracer tests	Rocky Coulee flow top		--	3 holes per set		--	1 test		--	1(7) = 7 days
			Cohassett flow top		3 holes per set	3 holes per set		1 test	1 test**		1(7) = 7 days	1(60) = 60 days
			Cohassett flow bottom		3 holes per set	3 holes per set		1'test	1 test**		1(7) = 7 days	1(60) = 60 days
			McCoy Canyon flow top		--	3 holes per set		--	1 test		--	1(7) = 7 days
			Umtanum flow top		--	3 holes per set		--	1 test		--	1(7) = 7 days
				* P1 = first priority test (see Section 3.1.2.2.1 of volume III). P2 = second priority test etc.			** involve use of non-conservative tracer's * 1 test over entire hole plus 2 shorter tests over selected intervals			*1 test requires ~1 day for completion		
Drift Boreholes		Cluster test room	Cohassett interior	9(P1) (all cluster room holes)	--	--	9(3)* = 27 tests	--	--	27(1)* = 27 days	--	--
		Chamber test room	Cohassett interior	17(P1) (all chamber room holes)	--	--	17(3) = 51 tests	--	--	51(1) = 51 days	--	--
		Exploratory Boreholes	Cohassett interior	4(P1) (all exploratory boreholes)	--	--	4(16)** = 64 tests	--	--	64(1) = 64 days	--	--
							* one test over entire borehole + 2 shorter interval tests ** one test over entire borehole + 15 separate tests 0-20 m separations.			*1 test requires ~1 day for completion		
Cluster Test		Cluster test room	Cohassett interior	9 holes per test (P1)	9 holes per test	--	1 test	1 test*	—	1(180)* = 180 days	1(180) = 180 days	--
							* involves multiple fluid injection rates.			*1 test requires ~180 days for completion		
Chamber Room Test		Chamber room	Cohassett interior	17 holes + chamber room (P1)	17 holes plus chamber room	--	1 test	1 test*	--	1(365)* = 365 days	1(365) = 365 days	--
							* multiple chamber volumes tested.			*1 test requires ~365 days for completion		
Tracer Tests		Cluster Boreholes	Cohassett interior	9 holes per test (P1)	9 holes per test	--	1 test	1 test*	--	1(365)* = 365 days	1(365) = 365 days	--
							* involves use of non-conservative tracer(s).			*1 test requires ~365 days for completion		

(a) Data to be acquired during Phase I & II
(b) Post Phase II data
(c) Post Phase II data.

TABLE 3-20. Correlation of Borehole Test Results.

Borehole Location	Test Results Correlated with Data from(*)
Individual boreholes drilled from Exploratory Shaft into	
• flow tops and interbeds	• surface boreholes (constant drawdown and constant discharge tests)
• flow interiors	• surface boreholes (ratio, cross hole, pulse, and constant head injection tests) • individual boreholes surrounding cluster and chamber tests (constant head injection) • exploratory boreholes cored from drift (constant head injection)
Cluster test in Cohassett flow interior	Flow interior testing • pared surface boreholes (ratio and cross hole tests) • chamber (ventilation test) • pared shaft boreholes (ratio and/or cross hole tests)
Individual boreholes surrounding chamber in Cohassett flow interior	Flow interior testing • surface boreholes (pulse and constant head injection tests) • shaft boreholes (constant head injection test) • individual boreholes in cluster and exploratory boreholes (constant head injection tests)
Exploratory boreholes drilled from drift into Cohassett flow interior	Flow interior testing • surface boreholes (pulse and constant head injection test) • shaft boreholes (constant head injection test) • individual chamber piezometers and cluster boreholes (constant head injection test)

* Principal hydrologic test planned in ES from Table 3.1.

ITEM REFERENCE: SECTION 17.2.7, PAGE 17.2-26,.PARAGRAPH 4

NRC COMMENT

HYDROLOGIC ISOLATION ASSESSMENT TECHNIQUES AND ANALYSIS METHODS ARE INADEQUATELY COVERED

STATUS

AGREED

BWIP RESPONSE

ES TEST PLAN WILL PROVIDE DETAILS

ITEM REFERENCE: Section 17.2.7, page 17.2-26, paragraph 4

17.2.7.2 Hydrologic Isolation Assessment (Test Program Objective 2 (Phase II). Testing initiated during the breakout of the exploratory shaft will be continued. Inflow tests will be performed utilizing the horizontal holes drilled above and below the shaft station in the selected candidate repository horizon. These holes will be used to monitor the changes in head as the excavation of the Exploratory Shaft - Phase II tunnels progresses. Consideration will be given to the use of tracers to determine effective porosity and dispersion. Additional porthole tests will be conducted in the exploratory shaft to ascertain vertical hydraulic conductivity of flows above the selected candidate repository flow. These tests will be performed to aid in assessment of the isolation potential of the flows above the selected candidate repository flow.

NRC COMMENT: Line 34-bottom, "17.2.7.2 Hydrologic ... repository flow." /3,9.10.

STATUS: Agreed

BWIP RESPONSE: Exploratory Shaft Test Plan will provide needed details.

ITEM REFERENCE: SECTION 17.2.7, PAGE 17.2-26, PARAGRAPH 4

BWIP RESPONSE 11/83

SECTIONS 3.2 AND 3.3 PRESENT DETAILS ON PLANNED HYDROLOGIC TESTING TECHNIQUES, ANALYSES, PRIORITIES AND SCHEDULES FOR PORTHOLE TESTING ABOVE AND BELOW THE REFERENCE CANDIDATE HORIZON. THESE DISCUSSIONS CENTER ON THE POSSIBLE USE OF SINGLE AND MULTIPLE HOLE TESTS PENETRATING FLOWTOP AND BASALT FLOW INTERIORS. DATA COLLECTED INCLUDE HYDRAULIC CONDUCTIVITY, STORATIVITY, EFFECTIVE POROSITY AND DISPERSIVITY. GROUNDWATER SAMPLES ARE PLANNED TO BE COLLECTED UNDER IN SITU TEMPERATURE AND PRESSURES. HYDRAULIC HEADS MEASURED ARE ANTICIPATED TO BE DISTURBED BY SHAFT EMPLACEMENT AND NEARBY TESTING -- THUS THE APPLICABILITY OF THESE HEAD MEASUREMENTS TO DEFINING THE LOCAL UNDISTURBED HEAD DISTRIBUTION IS QUESTIONED.

STATUS

PENDING -- TO BE CLOSED UPON ISSUANCE OF ES TEST PLAN.

TABLE 3-1. Hydrologic Information Obtained from the Exploratory Shaft.

Data Source	Hydraulic Conductivity and Storativity	Effective Porosity, Dispersivity and Distribution Coefficient	Hydraulic Heads[a]	Groundwater Samples
Exploratory Shaft Boreholes	Low Transmissive Zones ● constant head injection* ● pulse ● cross hole tests High Transmissive Zones ● constant drawdown* ● constant discharge*	Low Transmissive Zones[b] ● radial flow* ● dilution methods High Transmissive Zones ● recirculation* ● convergent flow* ● dilution methods	Low Transmissive Zones ● heads monitored in response to testing High Transmissive Zones ● heads monitored in response to testing ● absolute and differential heads monitored	Low Transmissive Zones ● not planned High Transmissive Zones ● sampling planned
Long Exploratory Boreholes Cored into Cohassett from drift	● constant head injection* ● pulse	not planned	● heads monitored in response to testing	not planned
Boreholes Cored from Chamber room into Cohassett flow interior (holes are piezometers for chamber test)	● constant head injection* ● pulse ● cross hole test	not planned though tracer tests are possible after chamber test is completed.	heads monitored in response to chamber test	not planned
Multiple Borehole Cluster Test in Cohassett flow interior	● constant head injection* ● pulse ● cross hole test*	● radial flow* ● dilution methods	heads monitored in response to cluster testing	not planned
Chamber Test (large scale hydrology test) in Cohassett flow interior	● direct measurement of water inflow[c]* ● ventilation system*	not planned though borehole to chamber tracer tests are possible following chamber test.	chamber will be maintained at atmospheric pressure. Head measurement not appropriate.	water seeps on chamber walls can be sampled

* Primary test planned.

(a) Natural, undisturbed heads may be strongly influenced by shaft construction.

(b) Tracer testing from shaft is possible but not of high priority (primary tracer testing in high transmissive zones will be in surface boreholes).

(c) Water measurement technique will be function of inflow rate.

TABLE 3-2. Hydrologic Test Scheduling Estimates.

Borehole Locations				Number of Boreholes: High Priority[a]	Number of Boreholes: Confirmatory[b]	Number of Boreholes: Contingency[c]	Number of Tests (# of holes) (# of tests per hole) = total number of tests: High Priority[a]	Number of Tests: Confirmatory[b]	Number of Tests: Contingency[c]	Test Time (# of tests) (test time) = total test time: High Priority[a]	Test Time: Confirmatory[b]	Test Time: Contingency[c]
Shaft Boreholes	single hole test	Low transmissive zones (interiors)		13(P1)*	54(P3)	5(P5)	13(3)* = 39 tests	54(3) = 162 tests	5(3) = 15 tests	39(1)* = 39 days	162(1) = 162 days	15(1) = 15 days
		High transmissive zones (flow tops/interbeds)		13(P2)	26(P4)	11(P6)	13(3) = 39 tests	26(3) = 78 tests	11(3) = 33 tests	(39)(1) = 39 days	78(1) = 78 days	33(1) = 33 days
	multiple hole test	Cross hole tests	BH#2 interior		4 holes per set	4 holes per set		1 test in one set	2 tests in two sets		1(100) = 100 days	2(100) = 200 days
			Rocky Coulee interior		6 holes per set	6 holes per set		1 test in one set	2 tests in two sets		1(100) = 100 days	2(100) = 200 days
			McCoy Canyon interior		2 holes per set	2 holes per set		1 test in one set	2 tests in two sets		1(100) = 100 days	2(100) = 200 days
			Umtanum interior		5 holes per set	5 holes per set		1 test in one set	2 tests in two sets		1(100) = 100 days	2(100) = 200 days
		Tracer tests	Rocky Coulee flow top		--	3 holes per set		--	1 test		--	1(7) = 7 days
			Cohassett flow top		3 holes per set	3 holes per set.		1 test	1 test**		1(7) = 7 days	1(60) = 60 days
			Cohassett flow bottom		3 holes per set	3 holes per set		1 test	1 test**		1(7) = 7 days	1(60) = 60 days
			McCoy Canyon flow top		--	3 holes per set		--	1 test		--	1(7) = 7 days
			Umtanum flow top		--	3 holes per set		--	1 test		--	1(7) = 7 days
				* P1 = first priority test (see Section 3.1.2.2.1 of volume III). P2 = second priority test etc.			** involve use of non-conservative tracer's * 1 test over entire hole plus 2 shorter tests over selected intervals			*1 test requires ~1 day for completion		
Drift Boreholes		Cluster test room	Cohassett interior	9(P1) (all cluster room holes)	--	--	9(3)* = 27 tests	--	--	27(1)* = 27 days	--	--
		Chamber test room	Cohassett interior	17(P1) (all chamber room holes)	--	--	17(3) = 51 tests	--	--	51(1) = 51 days	--	--
		Exploratory Boreholes	Cohassett interior	4(P1) (all exploratory boreholes)	--	--	4(16)** = 64 tests	--	--	64(1) = 64 days	--	--
							* one test over entire borehole + 2 shorter interval tests ** one test over entire borehole + 15 separate tests 0-20 m separations.			*1 test requires ~1 day for completion		
Cluster Test		Cluster test room	Cohassett interior	9 holes per test (P1)	9 holes per test	--	1 test	1 test*	--	1(100)* = 100 days	1(100) = 100 days	--
							* involves multiple fluid injection rates.			*1 test requires ~100 days for completion		
Chamber Room Test		Chamber room	Cohassett interior	17 holes + chamber room (P1)	17 holes plus chamber room	--	1 test	1 test*	--	1(365)* = 365 days	1(365) = 365 days	--
							* multiple chamber volumes tested.			*1 test requires ~365 days for completion		
Tracer Tests		Cluster Boreholes	Cohassett interior	9 holes per test (P1)	9 holes per test	--	1 test	1 test*	--	1(365)* = 365 days	1(365) = 365 days	--
							* involves use of non-conservative tracer(s).			*1 test requires ~365 days for completion		

(a) Data to be acquired during Phase I & II
(b) Post Phase II data
(c) Post Phase II data.

ITEM REFERENCE: SECTION 17.2.7, PAGE 17.2-27, PARAGRAPH 1

NRC COMMENT

THE WATER IN-FLOW TEST TECHNIQUES AND ANALYSIS METHODS ARE INADEQUATELY COVERED

STATUS

AGREED

BWIP RESPONSE

ES TEST PLAN WILL PROVIDE DETAILS

ITEM REFERENCE: Section 17.2.7, page 17.2-27, paragraph 1

Based on the conditions measured in the inflow test around the shaft station and following Exploratory Shaft - Phase II excavation, the need for a large-scale water flow test will be determined. If water inflows are extremely small, a drift that can be isolated and ventilated will be used to measure water inflow on a large area. If water inflows are somewhat larger than expected, it is possible that only measurements of water volume flowing into the sump will be needed or required to determine total water inflow over a large area. The exact features of this test cannot be determined until observations of actual underground conditions are conducted. Key parameters to be measured as part of the hydrologic isolation assessment are presented in Table 17-9.

NRC COMMENT: Lines 1-11, "Based on the conditions ... presented in Table 17-9."/3,9,10.

STATUS: Agreed

BWIP RESPONSE: Exploratory Shaft Test Plan will provide needed details.

ITEM REFERENCE: SECTION 17.2.7, PAGE 17.2-27, PARAGRAPH 1

BWIP RESPONSE 11/83

A CHAMBER TEST OR ROOM SCALE TEST IS DISCUSSED IN SECTION 3.4, VOLUME II OF THE ES TEST PLAN. IT WILL:

- PROVIDE A LARGE SCALE MEASUREMENT OF THE HYDRAULIC CONDUCTIVITY AND STORATIVITY OF THE COHASSETT FLOW INTERIOR.
- PROVIDE A BETTER EVALUATION OF THE SIZE OF A REPRESENTATIVE VOLUME OF COHASSETT FLOW INTERIOR.
- PROVIDE CORRELATION BETWEEN SINGLE AND CLUSTER BOREHOLE SCALE TESTS VERSUS LARGER TESTS.
- QUANTIFY THE EFFECT THE DRIFT EXCAVATION HAS ON NEAR-FIELD HYDRAULIC CONDUCTIVITY.

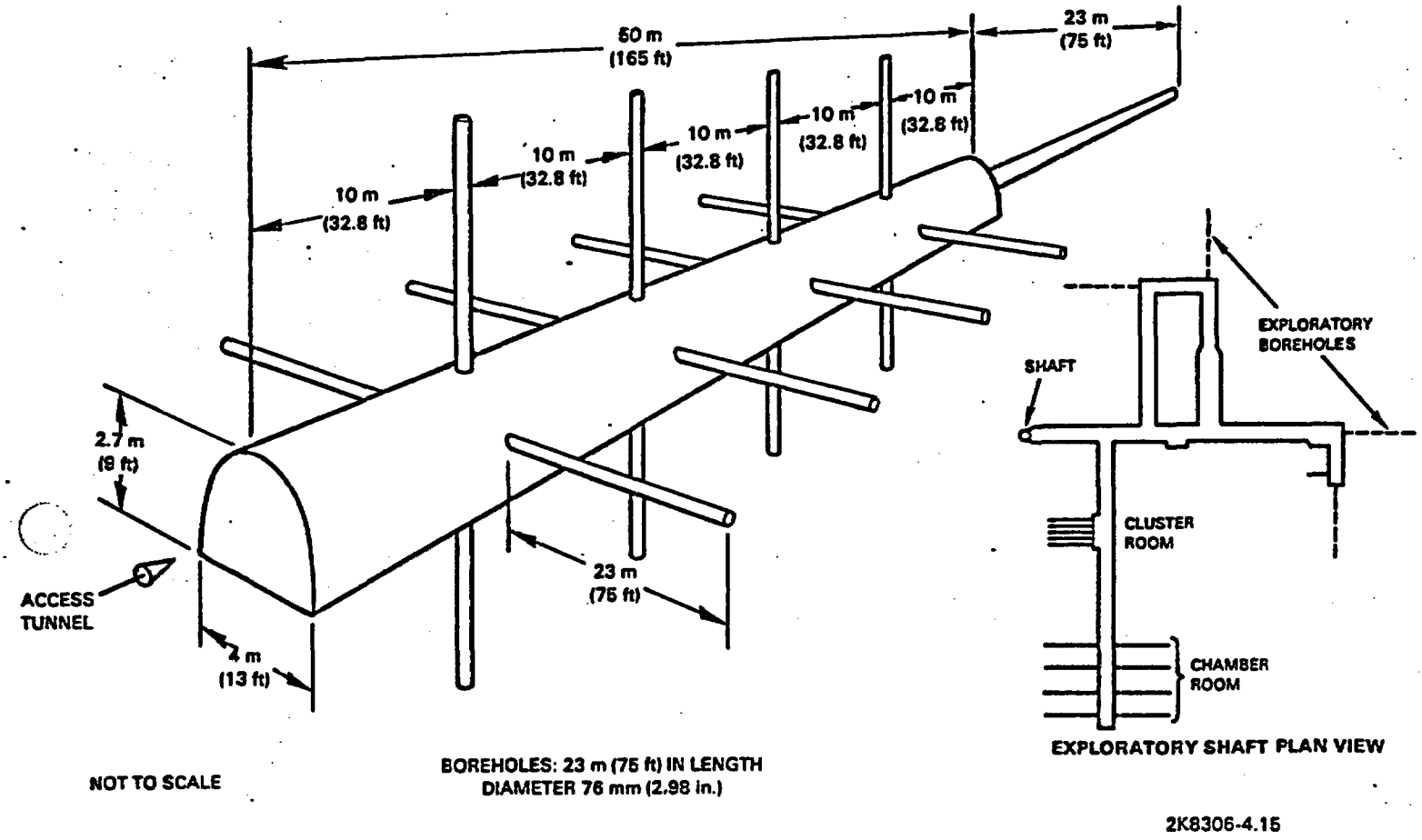


FIGURE 3-17. Proposed Borehole Configuration Surrounding Chamber Experiment.

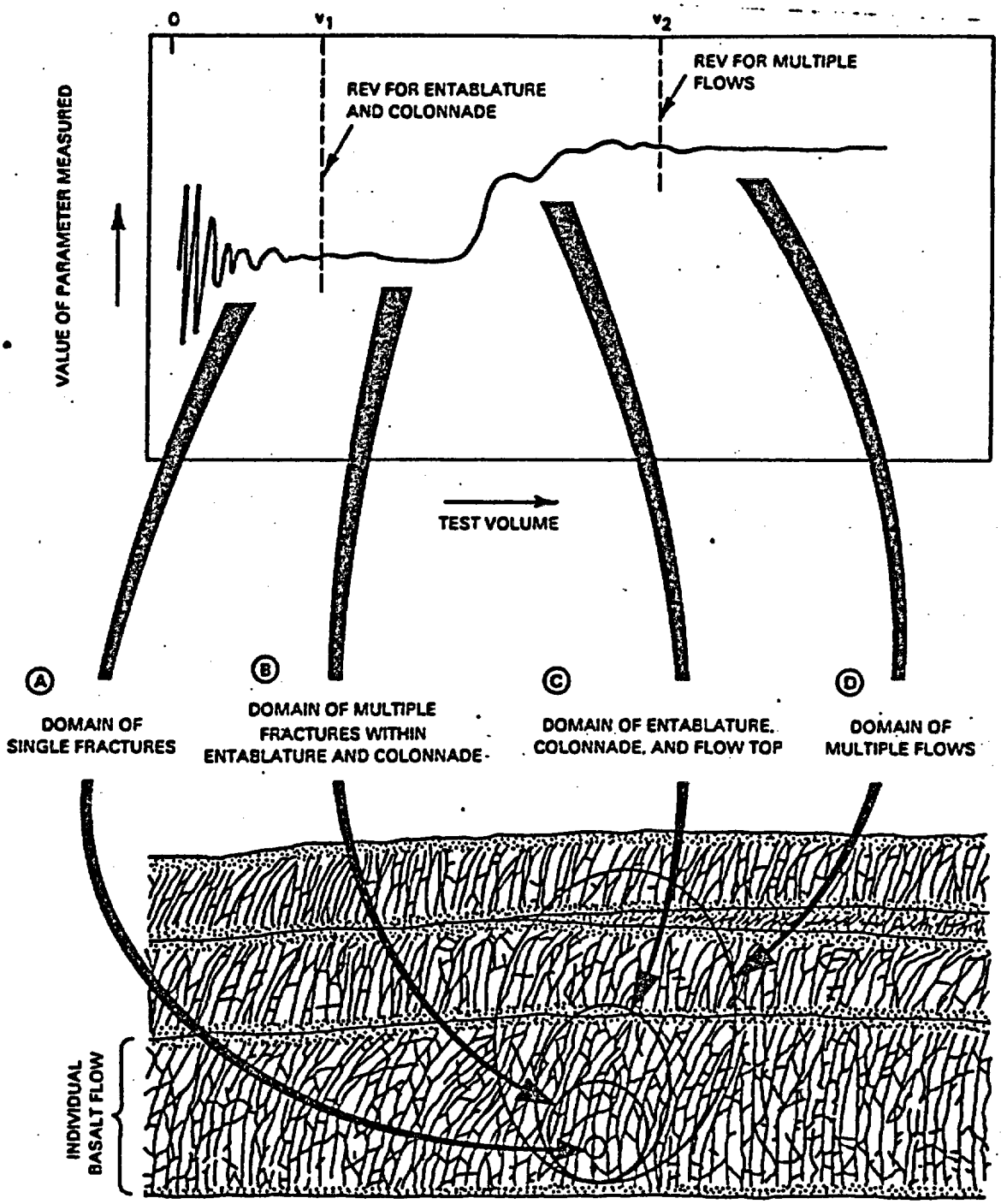


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FIGURE 3-4. Schematic Definition of a Representative Elementary Volume as Applied to Basalt (after Carnahan, C.L., and Others, 1983).

TABLE 3-24. Proposed Length of Open and Sealed Portions of Chamber Piezometers.

Total Piezometer Length m (ft)	Average Number of Intervals Monitor Per Piezometer	Average Length of Monitored Interval m (ft)	Average Number of[a] Fractures Monitored in Each Interval	Average Length of Packed Off or Grouted Zone m (ft)
23 (75)	4	2 (6.5)	20	3-4 (f10-13)

(a) Based on minimum fracture abundance in Cohassett of 10 fractures per meter (3 per foot). (range in fracture abundance is ~10 to 20 fractures per meter (~3 to 6 per foot) - see Appendix A).

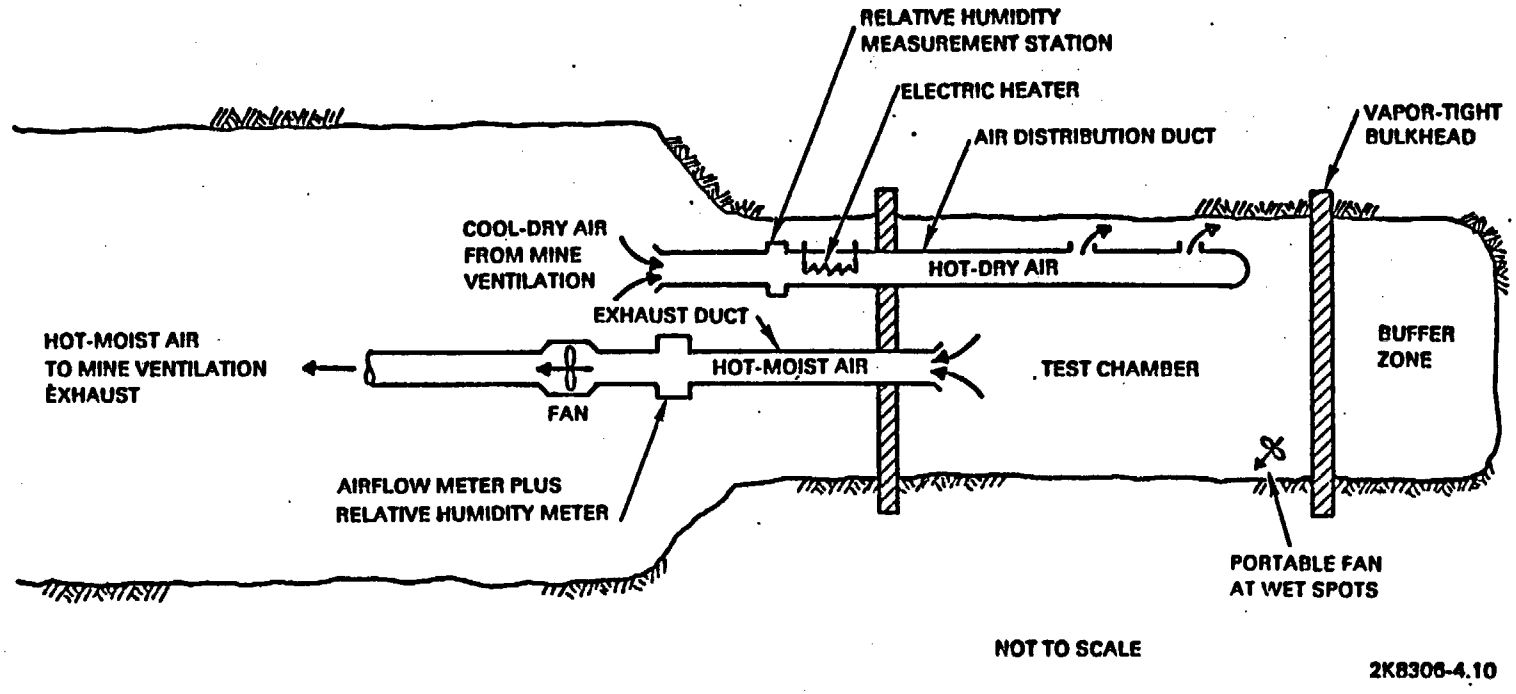


FIGURE 3-18. Open Circuit Ventilation Scheme
(after Watkins, D.J., 1982).

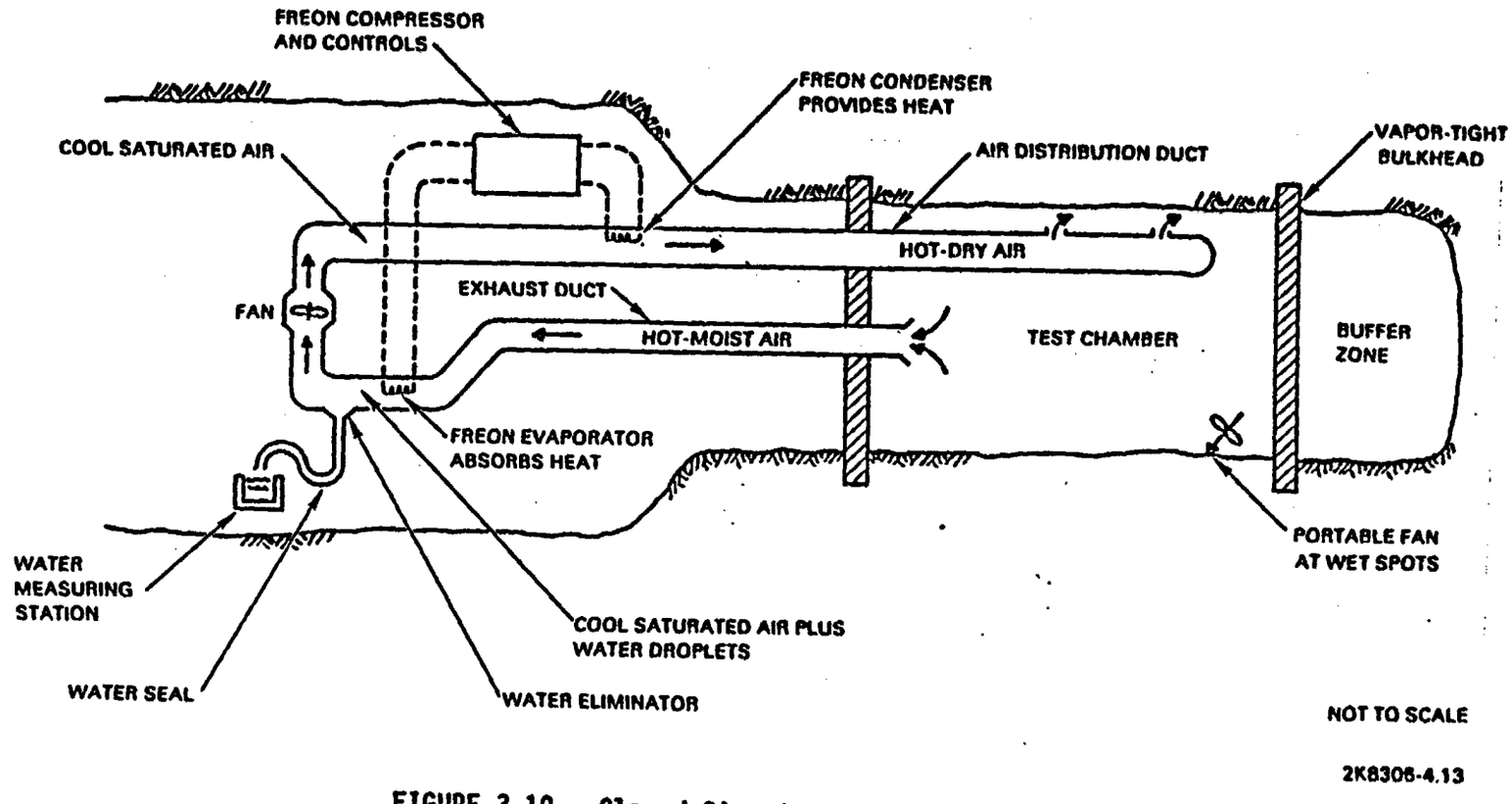


FIGURE 3-19. Closed Circuit Ventilation System (after Watkins, D.J., 1982).

TABLE 3-23. Approximate Times to Steady State Conditions and Steady State Inflows for the Cohassett Horizon.

Hydraulic Conductivity (m/sec)	Storativity	Time to Reach Steady State Inflow (days)	Steady State Inflow (ℓ/min)	Steady Inflow (gpm)
10^{-8}	10^{-4}	3×10^{0}	3.2×10^{1}	8.5×10^{0}
10^{-8}	10^{-6}	3×10^{-2}	3.2×10^{1}	8.5×10^{0}
10^{-10}	10^{-4}	3×10^{2}	3.2×10^{-1}	8.5×10^{-2}
10^{-10}	10^{-6}	3×10^{0}	3.2×10^{-1}	8.5×10^{-2}
10^{-12}	10^{-4}	3×10^{4}	3.2×10^{-3}	8.5×10^{-4}
10^{-12}	10^{-6}	3×10^{2}	3.2×10^{-3}	8.5×10^{-4}

(after Watkins 1982)

TABLE 3-29. Correlation of Chamber Test Results.

Results Compared to Chamber Test Measurements	**Multiple Borehole Sites**
	• Surface boreholes (ratio and/or cross hole tests)[a]
	• Shaft boreholes (cross hole tests)
	• ES cluster boreholes (cross hole tests)
	Single Boreholes
	• Surface boreholes (ratio, pulse, cross hole, and constant head injection test)
	• Shaft boreholes (constant head injection tests)
	• Single boreholes in cluster (constant head injection tests)
	• Single boreholes surrounding chamber (constant head injection test)
	• Exploratory boreholes extending from the ES (constant head injection tests)

(a) Primary test available or planned for use.

ITEM REFERENCE: SECTION 17.2.4, PAGE 17.2-19, PARAGRAPH 6

NRC COMMENT

INCLUDE WORK ELEMENTS S.1.24.C AND S.1.25.C

STATUS

AGREED

BWIP RESPONSE

ES TEST PLAN WILL IDENTIFY ADDITIONAL WORK ELEMENTS

ITEM REFERENCE: Section 17.2.4, page 17.2-19, paragraph 6

S.1.5.A Determine the orientation, distribution, aperture infilling (secondary mineralization), and origin of fractures, discontinuities, and heterogeneities within the candidate repository horizons.

S.1.7.A Determine the stratigraphic characteristics of the flows above and below the candidate repository horizons.

S.1.8.A Determine the structural, textural, mineralogic, and petrographic characteristics of the rocks above and below the candidate repository horizons.

S.1.9.A Determine the orientation, distribution, aperture infilling (secondary mineralization), and origin of fractures, discontinuities, and heterogeneities within rocks above and below the candidate repository horizons.

S.1.10A Determine the presence and characteristics of other possible anomalies that could serve as zones of greater permeability.

S.1.26.C Determine the hydrochemistry of the basalt groundwater system.

S.1.30.C Develop a conceptual hydrologic model that can be used to evaluate the hydrogeologic setting of the repository and as input to the performance assessment models.

S.1.35.C Determine the groundwater content of the host rock.

R.1.9.A Determine the potential for subsidence caused by mine openings.

W.2.1.A Determine the effect on radionuclide mobility of changes in the primary and secondary mineralogical conditions in the near field and far field of the repository, along the expected pathway to the biosphere.

W.2.10.C Determine the method and technique that can be utilized to provide valid in situ Eh measurements for the reference repository location.

W.2.8.A Determine acceptable release rates of key radionuclides from the engineered system as a function of containment time, groundwater travel time to the accessible environment, and water flow through the repository.

NRC COMMENT: Line 17./9 -- "Work elements S.1.24.C and S.1.25.C should be included."

STATUS: Agreed

BWIP RESPONSE: ES Test Plan will identify additional work elements and work elements S.1.25.C and S.1.25.C will be added.

ITEM REFERENCE: SECTION 17.2.4, PAGE 17.2-19, PARAGRAPH 6

BWIP RESPONSE 11/83

THESE WORK ELEMENTS ARE IDENTIFIED IN SECTION 3.3 (BOREHOLE TEST PROGRAM), SECTION 3.4 (CHAMBER TEST PROGRAM) AND SECTION 3.5 (TRACER TEST PROGRAM) VOLUME II OF THE ES TEST PLAN. A SUMMARY OF THE HYDROLOGIC TESTS AND TIME REQUIREMENTS IS CONTAINED IN SECTIONS 3.0 AND 3.1 OF VOLUME II. A POINT RAISED IN REGARD TO WORK ELEMENT S.1.25C (COLLECTION OF UNDISTURBED HYDRAULIC HEADS), IS THAT THE SHAFT ITSELF WILL LIKELY CREATE A MAJOR LOCAL HEAD DISTURBANCE, THEREFORE HEADS MEASURED FROM THE SHAFT PORTHOLES WILL BE QUESTIONABLE.

STATUS

PENDING -- TO BE CLOSED UPON ISSUANCE OF ES TEST PLAN.

TABLE 3-21. Primary Sources of Hydrologic Data Planned from Site Characterization Activities.

Test Facility	Rock Volume Tested: small (single hole tests)	Rock Volume Tested: large (multiple hole tests)	Hydraulic Conductivity and Storativity	Effective Porosity Dispersivity and Distribution Coefficient	Hydraulic Heads[a]	Groundwater Samples
Surface Boreholes	X	X	X	X	X (drill/test heads)	X
Surface Based Piezometers					X	X[b]
Exploratory Shaft Boreholes[c]						
Cohassett flow interior	X		X			
Cohassett flowtop/bottom	X		X		X (disturbed by ES)	x
Non-candidate horizon interiors[d]	X		X			
Non-candidate horizon flowtop/ interbeds	X		X		X (disturbed by ES)	X
Large Scale Chamber Test		X	X			
Piezometers Drilled from Chamber	X		X			
Borehole Cluster Test	X	X	X	X		
Exploratory Shaft Boreholes	X		X			

(a) Heads usable for defining potentiometric surface (not heads measured in response to testing).
(b) Very minimal use for groundwater sampling so as to not disturb head measurements.
(c) See Table 3.7 for test priority on ES boreholes.
(d) Testing in these boreholes is data and schedule dependent.

TABLE 3-3. Borehole Input to Work Elements.

Work Element Identification	Topic of Work Element	Results from Borehole Tests Address
S.1.24C	Hydraulic Properties	X (direct measurements)
S.1.25C	Undisturbed Hydraulic Heads	
S.1.26C	Hydrochemistry	X (direct sampling)
S.1.27C	Geometry and Interaction between Flow Systems	X (input to models)
S.1.28C	Vertical Groundwater Movement	X (input to models)
S.1.29C	Structural and Stratigraphic Influences	X (direct data only if such an influence is encountered)
S.1.30C	Conceptual Groundwater Model	X (input to model)
S.1.31C	Numerical Model Development	
S.1.32C	Hydrogeologic Conditions Since Quaternary	
S.1.33C	Numerical Model Predictions	X (data input)
S.1.34C	Modeling Uncertainty	X (refinement of model input)
S.1.35C	Groundwater Content	X (direct measurement)
S.1.36C	Groundwater Circulation	X (input to models)

- Hydraulic conductivity and storativity of noncandidate flow interiors as tested from the ES.

- Hydraulic conductivity and storativity of flow tops and interbeds as tested from the ES.

- Groundwater samples collected under in situ temperatures and pressures.

TABLE 3-22. Chamber Test Input to Work Elements.

Work Element Identification	Topic of Work Element	Results from Chamber Test Addresses
S.1.24C	Hydraulic Properties	X (direct measurement)
S.1.25C	Undisturbed Hydraulic Heads	
S.1.26C	Hydrochemistry	
S.1.27C	Geometry and Interaction between Flow Systems	X (input to model)
S.1.28C	Vertical Groundwater Movement	X (input to model)
S.1.29C	Structural and Stratigraphic Influences	
S.1.30C	Conceptual Groundwater Model	X (input to model)
S.1.31C	Numerical Model Development	
S.1.32C	Hydrogeologic Conditions Since Quaternary	
S.1.33C	Numerical Model Predictions	X (data input)
S.1.34C	Modeling Uncertainty	X (refinement of model input)
S.1.35C	Groundwater Content	
S.1.36C	Groundwater Circulation	X (input to models)

TABLE 3-31. Tracer Test Input into Work Elements.

Work Element Identification	Topic of Work Element	Results from Tracer Test Addresses
S.1.24C	Hydraulic Properties	X (direct measurement)
S.1.25C	Undisturbed Hydraulic Heads	
S.1.26C	Hydrochemistry	
S.1.27C	Geometry and Interaction between Flow Systems	
S.1.28C	Vertical Groundwater Movement	
S.1.29C	Structural and Stratigraphic Influences	
S.1.30C	Conceptual Groundwater Model	
S.1.31C	Numerical Model Development	
S.1.32C	Hydrogeologic Conditions Since Quaternary	
S.1.33C	Numerical Model Predictions	X (data input)
S.1.34C	Modeling Uncertainty	X (refinement of model input)
S.1.35C	Groundwater Content	
S.1.36C	Groundwater Circulation	

GEOMECHANICS

W. M. McCABE

ITEM REFERENCE: SECTION 4.1.3, PAGE 4.1-7, PARAGRAPH 1

NRC COMMENT

- SCATTER OF LABORATORY DATA FOR COMPRESSIVE STRENGTH INDICATES A LOWER THAN AVERAGE DESIGN STRENGTH SHOULD BE UTILIZED
- THIS ASPECT SHOULD BE ANALYZED IN EXPLORATORY SHAFT

STATUS

AGREED

BWIP RESPONSE

- FINAL DESIGN WILL USE TUNNEL STABILITY CRITERIA OBTAINED FROM EXPLORATORY SHAFT TEST
- PLAN FOR OBTAINING DATA FROM ES TEST WILL BE ELABORATED IN SCP

ITEM REFERENCE: Section 4.1.3, page 4.1-7, paragraph 1

A comparison of the basalt characteristics used in the repository conceptual design (see Table 4-1) with the laboratory results listed for the Umtanum flow in Table 4-2 shows agreement within 15 percent, except for the shear strength parameters (i.e., cohesion and angle of internal friction, ϕ. The laboratory-determined ϕ value, an important parameter indicating how the shear strength of a rock increases with confinement, was found to be 20 percent lower than estimated earlier. On the other hand, the experimentally determined cohesion was 40% higher than estimated. Of significance is the considerable scatter of laboratory data for compressive strength, both uniaxial and triaxial. Very high standard deviations observed for uniaxial strengths diminished only slightly with the addition of confining pressure. Sample identification, preparation, and testing techniques contributed significantly to this scatter. Such a wide variation of test results was also observed for porosity and tensile strength values.

NRC COMMENT: "of significance is ... uniaxial and triaxial."/3 -- "The considerable scatter in the strength data suggests that design should take this into account, e.g., by using a design strength significantly below the average. The second paragraph on this page confirms the suspicion that extremely optimistic (high) strength values have been used for the conceptual design, even though the third paragraph mitigates this somewhat. This aspect should be analyzed in the exploratory shaft."

STATUS: Agreed

BWIP RESPONSE: The final detailed design will be based on the tunnel stability criteria to be obtained from the Exploratory Shaft Test. A conservative approach will be taken in the upgraded conceptual design with regard to strength values. It should be noted that laboratory measured strength values will be used to estimate the rock mass strength along with geomechanic logging data for use in the upgraded conceptual design. In addition, data to be obtained from the ES test will be utilized to ascertain soundness of the approach. This plan will be further elaborated in Section 4.1.3 of the SCP.

UNIAXIAL COMPRESSIVE STRENGTHS OF RRL BASALT

		NO. OF SAMPLES	MEAN (MPA)	MEAN (PSI)	STANDARD DEVIATION (MPA)	STANDARD DEVIATION (PSI)
• COHASSETT	ENTABLATURE	18	292	42,400	19	2,760
	COLONNADE	11	288	41,800	38	5,520
• UMTANUM	ENTABLATURE	7	353	51,200	64	9,290
	COLONNADE	10	386	56,000	27	3,920

ITEM REFERENCE: SECTION 4.1.3, PAGE 4.1.7, PARAGRAPH 1

BWIP RESPONSE 11/83

PREVIOUS LABORATORY STRENGTH TESTS CONDUCTED UNDER LESS STRINGENT QUALITY CONTROL PROCEDURES; RELIABILITY OF RESULTS IS LOW.

RECENT TESTS BY BWIP ON RRL CORE SHOW HIGHER MEAN STRENGTHS AND SIGNIFICANTLY REDUCED SCATTER.

OPENING STABILITY AND ROCK MASS STRENGTH TO BE INVESTIGATED IN ES I AND II USING:

1. OPENING DEFORMATION MONITORING TEST
2. OPENING SUPPORT MONITORING TEST
3. ACOUSTIC EMISSION MONITORING TEST
4. ROOM SCALE ENLARGEMENT/MINE-BY TEST
5. HEATER TEST

STATUS

PENDING -- TO BE CLOSED UPON ISSUANCE OF TITLE II DESIGN.

ITEM REFERENCE: Section 4.1.3, paragraph 1

BWIP RESPONSE 11-29-83: As mentioned in Chapter 4 of the SCR, uncertainties in laboratory sample identification procedures (i.e., jointed vs. intact) and testing techniques used by testing contractors had reduced the reliability of data presented in the tables in that chapter. Recent testing of RRL core by BWIP under much stricter procedures has produced uniaxial compression test results showing significantly reduced scatter, typified by standard deviations of from 7% to 20% of the mean for flow interior zone population samples of four or more (see Rock Mechanics Data Package, SD-BWI-DP-041). Accordingly, only RRL test data is to be included in the BWIP design data base.

Additional data on laboratory-measured physical, mechanical, thermal, and thermomechanical properties will be obtained using samples from boreholes drilled in the ES test facility, including those holes extending out 300 m (1000 ft) or more in each direction. At that time, strength variability within the RRL can be better evaluated.

Observations of the stability of openings of various shapes and sizes at ambient temperatures at the reference repository horizon will be obtained during ES-I and II for assisting with the formulation of a rock mass failure criterion and a repository design criteria. The supporting tests are:

- Opening Deformation Monitoring (ES Test Plan, Vol. II, Sections 4.2.2 and 4.3.2)
- Opening Support Monitoring (ES Test Plan, Vol. II, Sections 4.2.3 and 4.3.3)
- Acoustic Emission Monitoring (ES Test Plan, Vol. II, Sections 4.2.4 and 4.3.4)
- Room Scale Enlargement/Mine-By Test (ES Test Plan, Vol. II, Section 4.3.9)

Additionally, stability observations for canister holes at elevated temperatures will be obtained during the Heater Test (ES Test Plan, Vol. II, Section 4.3.11) to assist in the design and failure criteria development effort.

RECOMMENDED STATUS: Pending. To be closed upon issuance of Title II Design.

ITEM REFERENCE: SECTION 4.2.3; PAGE 4.2-5, PARAGRAPH 4

NRC COMMENT

CONSIDER OTHER METHODS FOR ESTABLISHING STRESS DISTRIBUTION IN TUNNEL SIDEWALL

STATUS

AGREED

BWIP RESPONSE

- OVERCORING TESTS WILL BE CONDUCTED IN ES
- TEST PLAN AND SCP WILL DETAIL METHOD

ITEM REFERENCE: Section 4.2.3, page 4.2-5, paragraph 4

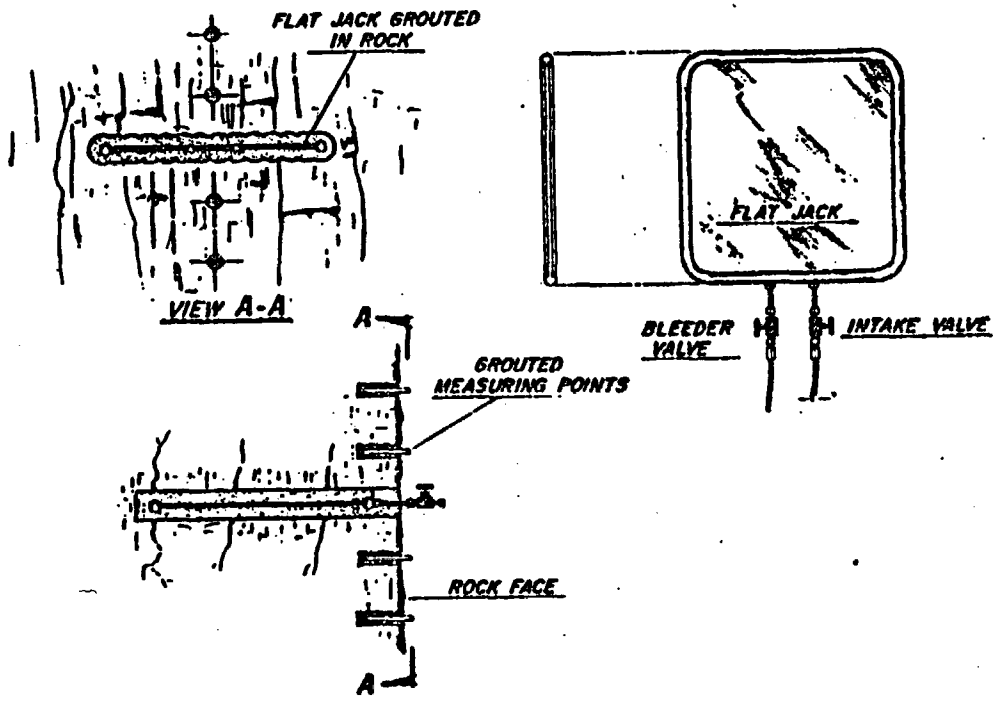
The single slot of Step 1 was drilled by successive boring of alternate 14-centimeter (5.5-inch) diameter holes and removal of the intervening web. During the drilling operation, vibrating wire stressmeters, installed in holes 5U03 and 5U04 (see Fig. 4-5), monitored the relaxation experienced by the rock mass. After installation of the flat jacks in the slot, the jacks were pressurized until the output from the vibrating wire stressmeter gauges returned to the pre-slot level. The pressure in the flat jacks, when each individual vibrating wire stressmeter gauge returned to its initial value, indicates the pattern of stress distribution (Fig. 4-6) from the tunnel wall into the rock perpendicular to the tunnel. This stress distribution, when compared to the theoretical stress concentration around an intact circular tunnel, also gives a qualitative indication of the depth of penetration of the blast-damage zone around the opening.

NRC COMMENT: "The pressure in the flat jacks ... perpendicular to the tunnel."/9,10 -- "The theoretical basis for using borehole stressmeters to infer cancellation stress is shakey. The procedure outlined for establishing the stress distribution in the tunnel sidewall is not very practical; other methods should be considered."

STATUS: Agreed

BWIP RESPONSE: The information regarding stress distribution around the opening was obtained as a by-product of the single slot test. In the ES, overcoring tests will be conducted to obtain information on stress redistribution around the opening. Further details regarding the test method will be included in the Exploratory Shaft Test Plan and Chapter 17 of the SCP.

FLATJACK CANCELLATION METHOD OF STRESS MEASUREMENT



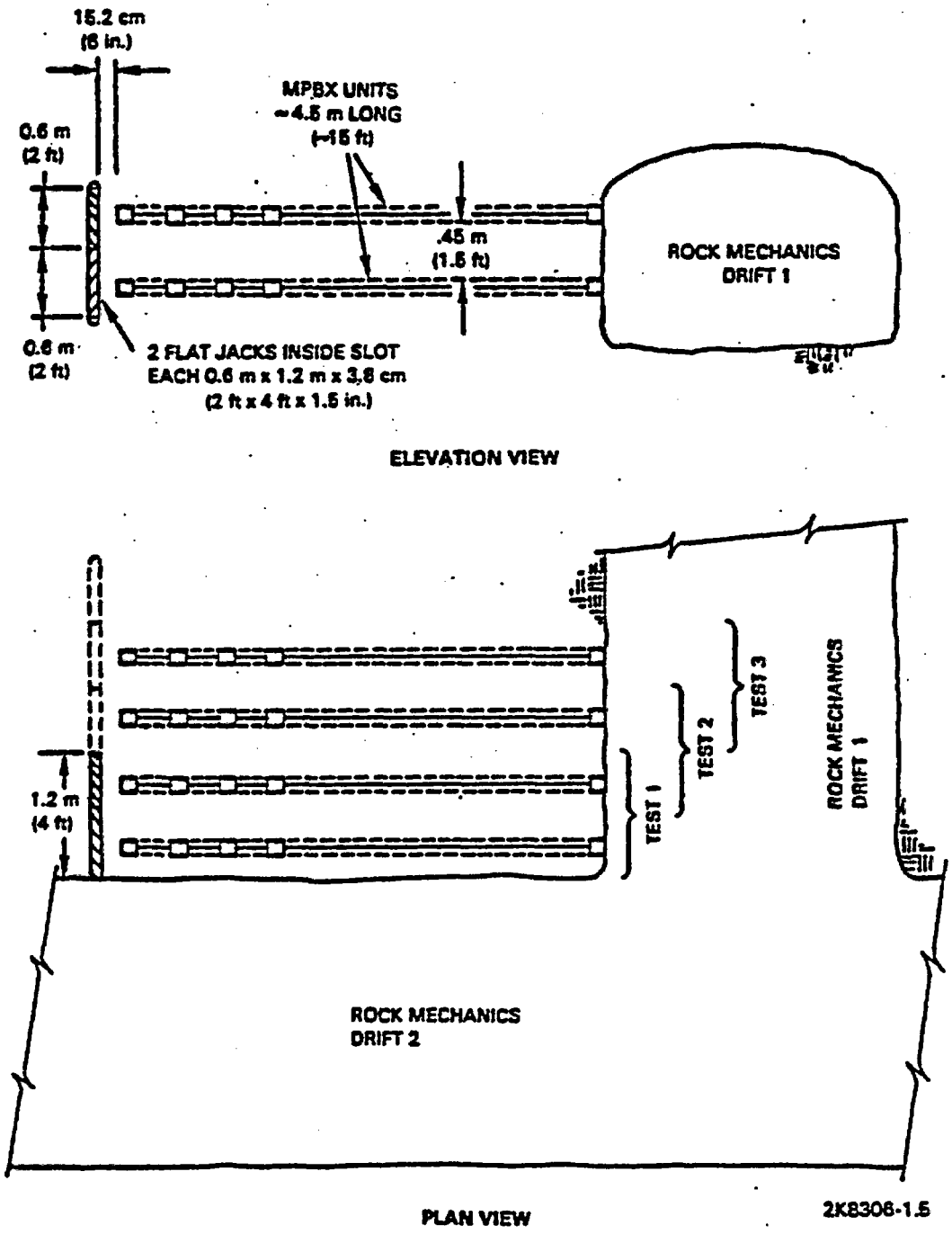


FIGURE 4-17. Test Layout for Vertical Large Flat jack Test.

ITEM REFERENCE: SECTION 4.2.3, PAGE 4.2-5, PARAGRAPH 4

BWIP RESPONSE 11/83

- STRESSES AROUND OPENINGS IN ES TO BE MEASURED USING BOTH OVERCORING AND FLAT-JACK CANCELLATION METHODS.

- SMALL FLAT-JACK TEST TO USE STANDARD GROUTED PIN TECHNIQUE FOR CANCELLATION MEASUREMENT; LARGE FLAT-JACK TEST EMPLOYS MULTIPLE POSITION EXTENSOMETERS AND DEFLECTOMETERS.

STATUS

PENDING -- TO BE CLOSED UPON ISSUANCE OF THE ES TEST PLAN.

ITEM REFERENCE: Section 4.2.3, page 4.2-5, paragraph 4

BWIP RESPONSE 11/29/83: In Phase II of the Exploratory Shaft program, the distribution of stresses in the vicinity of the opening is to be measured by both the overcoring and the flat-jack cancellation methods (see ES Test Plan, Vol. II, Sections 4.3.12 and 4.3.13). Small flat-jack tests are to be conducted in a manner which has been used and reported frequently in the field of rock mechanics. Deformation of the rock mass around the slot during cutting and application of the cancellation pressure is measured using rigid pins grouted into holes in the rock on both sides of the slot. In the event that these small flat-jack tests cannot be conducted successfully, the large flat-jack tests (see ES Test Plan, Vol.II, Section 4.3.8) included primarily for deformability measurements can also be employed for cancellation stress measurements. This is to be a non-standard test whereby deformations of the rock mass near the slot are measured using multiple-position borehole extensometers and deflectometers extending into the test region form an adjacent drift.

RECOMMENDED STATUS: Pending. To be closed upon issuance of the ES Test Plan

ITEM REFERENCE: SECTION 4.2.4, PAGE 4.2-11, PARAGRAPH 1

NRC COMMENT

- CAN ANY RELATIONSHIP BE ESTABLISHED BETWEEN BOREHOLE JACK TESTS AND FLAT JACK TESTS
- IF NOT, WHY USE AT REPOSITORY HORIZON

STATUS

AGREED

BWIP RESPONSE

- FIELD TESTS WILL ESTABLISH RELATIONSHIP
- IF BOREHOLE JACKING TESTS CANNOT BE VALIDATED, METHOD WILL NOT BE USED AT REPOSITORY HORIZON
- TEST METHOD VALIDATION WILL BE DISCUSSED IN SCP

ITEM REFERENCE: Section 4.2.4, page 4.2-11, paragraph 1

The test results obtained by the borehole jacking methods yielded substantially lower modulus values than the block test results. This is attributed to the inherent shortcomings of the borehole jacking method; namely, the effects of the smaller volume of stressed rock, jack platen/borehole radius mismatch, longitudinal bending of the jack, and the deformation of joints adjacent to and in the test interval. Similar tests have not been conducted at depth in the Umtanum or middle Sentinel Bluffs flows because of lack of access. When access to the repository horizon becomes available, borehole tests and possibly one or more of the large-scale tests available (i.e., flat jack, plate bearing, hydrostatic pressure, radial jacking, and room covergence tests) are likely to be required in the reference repository horizon to establish values of the deformation modulus needed for design and modeling.

NRC COMMENT: "The tests results obtained ... block test results."/9 -- "Test results of the Goodman-Jack and modified Goodman-Jack are reported. Both yield lower values than that of single-slot flat jack in the jointed block at the NSTF. Can any correlation be established between borehole jack tests and flat jack tests? If not, what is the purpose of using them again at the repository horizon?"

STATUS: Agreed

BWIP RESPONSE: The BWIP plans to conduct a series of field tests to establish the relationship between the borehole jacking test and the flat jack test. If the borehole jacking tests cannot be validated, this method will not be conducted at the repository horizon. No further clarification is deemed necessary at this point. A discussion on test method validation will be included in the SCP.

RATIOS OF E_{FIELD}/E_{LAB} FOR VARIOUS TYPES OF

FIELD DEFORMABILITY TESTS (HEUZE, 1980)

TYPE OF TEST	NO. OF RESULTS	MEAN	STANDARD DEVIATION
PLATE BEARING	27	0.32	0.26
TUNNEL RELAXATION	14	0.44	0.26
FLAT-JACK	10	0.54	0.27
BOREHOLE JACK	9	0.33	0.17
PRESSURE CHAMBER	8	0.45	0.22
PETITE SEISMIQUE	5	0.34	0.05
OTHERS	5	0.42	0.14

ITEM REFERENCE: SECTION 4.2.4, PAGE 4.2-11, PARAGRAPH 1

BWIP RESPONSE 11/83

- NO FIRM CONCLUSION ON RELATIONSHIP BETWEEN BOREHOLE JACKING AND LARGE SCALE DEFORMABILITY TEST RESULTS AT NSTF TO BE MADE UNTIL TESTS CONDUCTED AT IDENTICAL LOCATIONS.

- BOREHOLE JACKING TESTS INCLUDED IN ES ON STRENGTH OF:

  - USEFULNESS REPORTED WORLDWIDE
  - SPEED AND SIMPLICITY OF TEST

STATUS

PENDING -- TO BE CLOSED UPON ISSUANCE OF ES TEST PLAN.

ITEM REFERENCE: Section 4.2.4, page 4.2-11, paragraph 1

BWIP RESPONSE

No firm conclusion about the relationship between results from NSTF borehole jacking tests and those from the flatjack and block tests will be made until borehole tests can be conducted closer to the actual location of those large scale tests. Goodman jack tests conducted approximately 200 ft away in the heater tes areas have not clearly shown the anisotropic deformability test results. Nevertheless, borehole jacking tests have been included in the ES Test Plan on the strength of their usefulness as reported in other projects (El Rabaa, 1982 Bieniawski, 1978; Heuze, 1980) and the speed and simplicity of the test. Borehole jack test results will be "calibrated" for use in basalt based on results of large scale tests conducted in the NSTF and the ES. Its primary use will then be to complement crosshole seismic tests in establishing the spatial variability of rock mass deformation modulus values in the vicinity of the ES.

STATUS

To be closed upon issuance of the ES Test Plan.

REFERENCES

El Rabaa, A. W., Hustrulid, W. A. and Ubbes, W. S. (1982). "Spatical Distribution of Deformation Moduli Around the CSM/ONWI Room," Edgar Mine, Idaho Springs, Colorado, Proceeding 23rd Symposium on Rock Mechanics, Berkeley, CA.

Bieniawski, Z. T. (1978). "Determining Rock Mass Deformability: Experience from Case Histories," International Journal of Rock Mechanics, Mining Sciences and Geomechanics Abstracts, V.1.15.

Henze, F. E. (1980). "Scale Effects in the Determination of Rock Mass Strength and Deformability," Rock Mechanics, Vol. 12.

ITEM REFERENCE: SECTION 4.5.1, PAGE 4.5-1, PARAGRAPH 3, BULLET 3

NRC COMMENT

IMPROVE INSTRUMENTS TO WITHSTAND HIGH TEMPERATURES

STATUS

AGREED

BWIP RESPONSE

SCP WILL DESCRIBE ONGOING INSTRUMENT DEVELOPMENT PROGRAM

ITEM REFERENCE: Section 4.5.1, page 4.5-1, paragraph 3, bullet 3

The process of conducting the tests and interpreting the results for use in design was complicated by several factors:

- Empirical relationships between laboratory and field behavior at elevated temperatures have not been established as have similar relationships at ambient temperatures (e.g., expressions relating compressive strength to sample size and relating smaller-scale modulus test values to large-scale values).

- The relative importance of the system of discontinuities to the thermal behavior of a rock mass has not been established for rocks in general.

- Very few monitoring instruments now exist that are capable of extended operation at elevated temperatures. This consideration is further complicated by the fractured nature of the basalt and the potential for localized aberrations in stress and displacement fields.

NRC COMMENT: "Very few monitoring instruments ... at elevated temperatures."/3 -- "The heater tests reveal the poor performance of some state-of-the-art instruments at high temperatures. Much effort must be placed in improving the instruments before conducting tests in the exploratory shaft."

STATUS: Agreed

BWIP RESPONSE: The BWIP has been conducting instrument development work since the early stage of the program. Continuing efforts are being made to improve instrument performance in preparation of the ES tests. A brief statement regarding the status of the instrument development program will be included in Section 4.5.1 of the SCP.

INSTRUMENTS IDENTIFIED FOR DEVELOPMENT

- MULTIPLE POSITION BOREHOLE EXTENSOMETER (MPBX)
- DEFLECTOMETER
- VIBRATING WIRE STRESSMETER
- BOREHOLE DEFORMATION GAUGE (USBM TYPE)
- DOORSTOPPER GAUGE
- HYDRAULIC FRACTURING SYSTEM
- PIEZOMETER
- SEISMIC SURVEILLANCE SYSTEMS
  - ACOUSTIC EMISSION MONITORING
  - EARTHQUAKE MONITORING
- EXPLORATION SEISMIC SYSTEMS
  - CROSSHOLE SEISMIC TESTING
  - ANOMALY DETECTION (SEISMIC, RADAR, OTHERS)
- HYDRAULIC FLATJACK

ITEM REFERENCE: SECTION 4.5.1, PAGE 4.5-1, PARAGRAPH 3

BWIP RESPONSE 11/83

PRELIMINARY INSTRUMENTATION DEVELOPMENT NEEDS FOR ES HAVE BEEN IDENTIFIED.

PROGRAM FOR DEVELOPMENT HAS BEEN INITIATED (CONTRACT TO WOODWARD CLYDE CONSULTANTS).

SEPARATE EVALUATION BEING CONDUCTED BY ARCHITECT-ENGINEER.

STATUS

PENDING -- TO BE CLOSED BY START OF ES TESTING.

ITEM REFERENCE: Section 4.5.1, page 4.5-1, paragraph 3, bullet 3

BWIP RESPONSE 11-29-83: Instrumentation development needs based on tests to be conducted in the Exploratory Shaft facility and on monitoring required in the repository have been identified by the BWIP. A concentrated instrumentation development program has subsequently been initiated to execute the necessary tasks from writing of development test plans through prototype fabrication and performance testing. Priority has been given to instruments needed at the earliest date in the ES test program. Woodward-Clyde Consultants is now under contract for the development planning work. This effort is to be integrated with a currently separate and independent evaluation of instrumentation needs being prepared by the architect/engineer for the repository (Raymond Kaiser Engineers Inc./Parsons Brinckerhoff Quade & Douglas, Inc.)

RECOMMENDED STATUS: Pending. To be closed by the start of ES testing.

ITEM REFERENCE: SECTION 6.3.5, PAGE 6-12, PARAGRAPH 3

NRC COMMENT

- TEST PLANS AND SCHEDULES ARE VAGUE
- LACK OF PLANS FOR FULL-SCALE ROOM EXCAVATION IS A WEAKNESS
- NEED ACCESS TO TEST PROCEDURES
- NEED A DRAFT TEST PLAN PREPARED PER NUREG/CR-3065
- REFERENCE PLANS IN SCP

STATUS

AGREED

BWIP RESPONSE

- SCOP WILL STATE TEST RESULTS WILL BE INPUT TO DESIGN
- NUREG WILL BE UTILIZED
- DOCUMENT CLEARANCE WILL BE EXPEDITED

ITEM REFERENCE: Section 6.3.5, page 6-12, paragraph 3

NRC COMMENT: "In summary, the staff finds the vagueness in the test plans and the lack of details for the in situ tests, tight schedules, and the apparent conditional commitments to execute the tests make the evaluation of the proposed site characterization plan difficult. Lack of plans for full-scale room excavation to demonstrate the stability of repository openings during the Phase II testing is a weakness of the proposed site characterization program at the BWIP.

The NRC staff and DOE need to come to closure on what is an adequate in situ test plan. To do this the NRC staff needs early access to proposed test procedures. It is suggested that draft plans be provided to avoid a situation where plans are locked in and NRC comments will meet great resistance! It is suggested the NUREG/CR-3065 be used as a point of reference.

Detailed plans should be referenced in the SCP.

STATUS: Agreed

BWIP RESPONSE: A paragraph will be added to Section 10.1.1 of the SCP stating that results form in situ tests which serve to characterize the site will be input to the design in time to support the license application. A reference will be made to Chapter 17 of the SCP in situ testing details and plans.

NRUEG/CR-3065 will be used as a point of reference in future discussions of test planning. Action is underway to expedite the document clearance process.

Available detailed test plans will be referenced in the SCP.

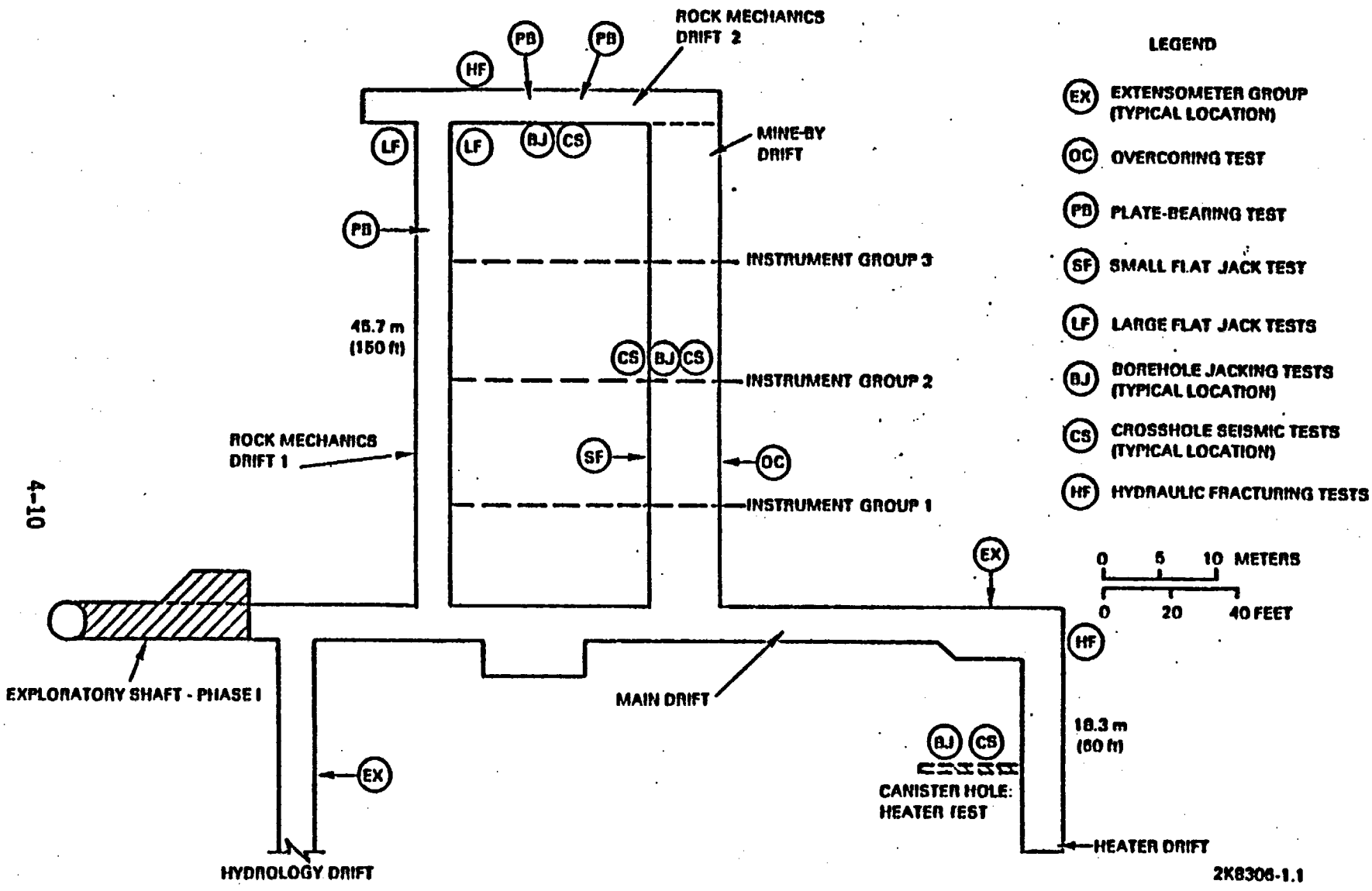
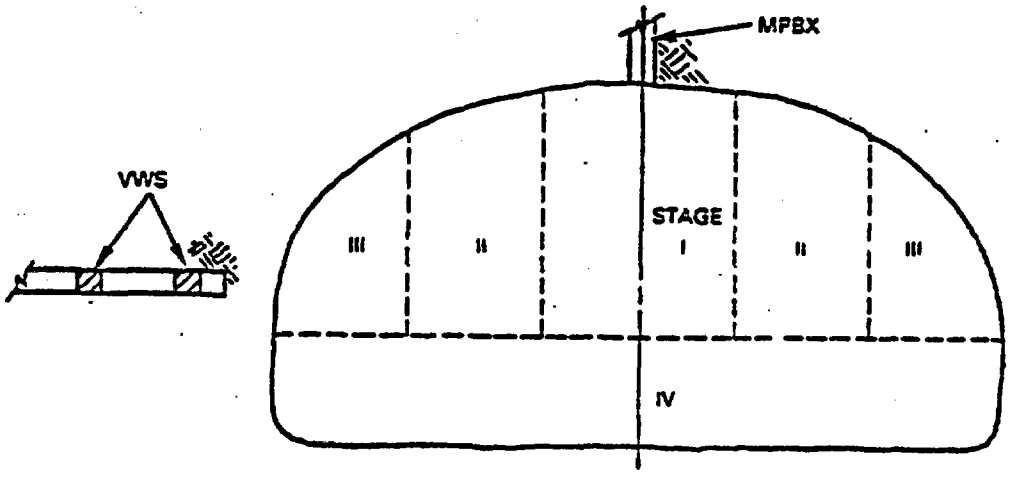


FIGURE 4-3. Plan View of ES-II Facility Showing Rock Mechanics Test Locations.



PROPOSED EXCAVATION SEQUENCE 1
(SECTION C-C)

ITEM REFERENCE: SECTION 6.3.5, PAGE 6-12, PARAGRAPH 3

BWIP RESPONSE 11/83

REPOSITORY ROOM SIZE OPENINGS TO BE EXCAVATED FOR AT LEAST TWO ES TESTS:

- HEATER TEST
  (HEATER TEST DRIFT DIMENSIONS ARE 12-FEET HIGH BY 20-FEET WIDE)

- ROOM SCALE ENLARGEMENT/MINE-BY TEST
  (MINE-BY DRIFT DIMENSIONS ARE 10-FEET HIGH BY 20-FEET WIDE)

STATUS

PENDING -- TO BE CLOSED UPON ISSUANCE OF ES TEST PLAN.

ITEM REFERENCE: Section 6.3.5, page 6-12, paragraph 3

BWIP RESPONSE 11-29-83: Full-scale repository room size openings are to be excavated at two different locations as part of the ES testing program. The Heater Drift is to be 6.1 m (20 ft) wide and 3.6 m (12 ft) high (see ES Test Plan, Vol. II, Section 4.3.11) in order to allow room for canister hole drilling equipment and heater test instrumentation. The Mine-By Drift is to be 6.1 m (20 ft) wide, 3.3 m (10 ft) high and 42.7 m (140 ft) long (see ES Test Plan, Vol. II, Section 4.3.9). It will be excavated partially by a staged enlargement technique and partially by a full-face operation.

RECOMMENDED STATUS: Pending. To be closed upon issuance of the ES Test Plan.

ITEM REFERENCE: SECTION 14.3.1, PAGE 14.3-38, PARAGRAPH 6

NRC COMMENT

WILL HEATERS BE PLACED IN HORIZONTAL HOLES IN ES-II

STATUS

AGREED

BWIP RESPONSE

WORK ELEMENT R.1.13.B AND TEST PLAN WILL PROVIDE DETAILS ON HEATED BOREHOLE TESTS IN ES-II

ITEM REFERENCE: Section 14.3.1, page 14.3-38, paragraph 6

Each model selected for use will be validated as required, and model selection will be influenced by results of validation studies. Validation of the near-field and canister-scale models will be achieved through comparison of predicted and measured rock-mass behavior. Continued evaluation of results from Near-Surface Test Facility tests will provide preliminary validation and selection of models currently under consideration.

NRC COMMENT: "Validation of the near-field and canister-scale models... and measured rock mass behavior."/10 -- "Will heaters be placed in horizontal holes drilled in the ES-II facility to measure rock-mass behavior."

STATUS: Agreed

BWIP RESPONSE: Plans for work element R.1.13.B will address heated borehole tests being planned for the ES-II facilities. The ES test plan will provide test details.

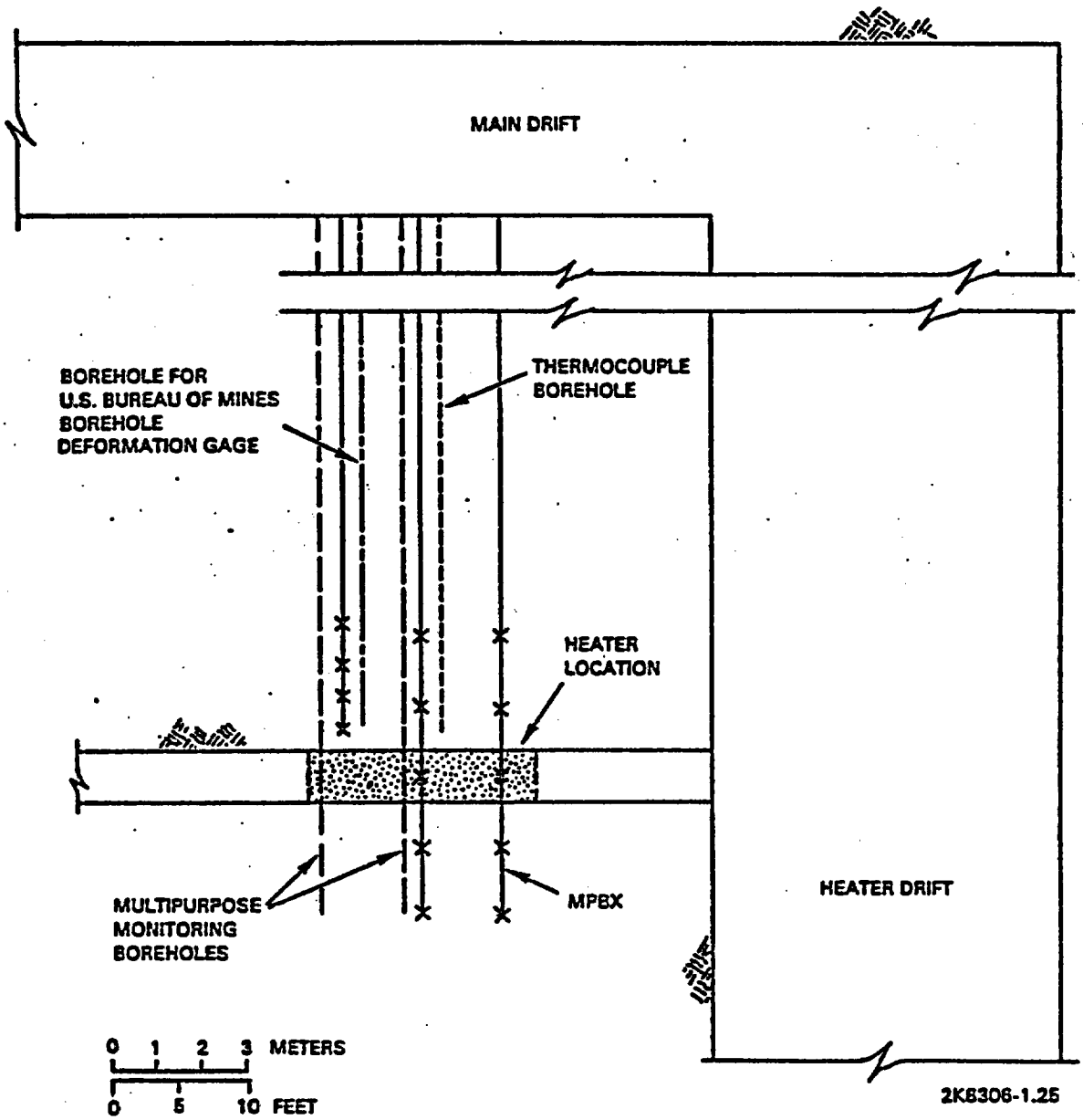


FIGURE 4-25. Plan View of Heater Test Layout.

ITEM REFERENCE: SECTION 14.3.1, PAGE 14.3-38, PARAGRAPH 6

BWIP RESPONSE 11/83

ES TEST PLAN INCLUDES HEATER TEST TO BE CONDUCTED IN 30-INCH DIAMETER HORIZONTAL HOLE.

STATUS

PENDING -- TO BE CLOSED UPON ISSUANCE OF THE ES TEST PLAN.

ITEM REFERENCE: Section 14.3.1, page 14.3-38, paragraph 6

BWIP RESPONSE 11-29-83: The current ES Test Plan includes a heater test (see ES Test Plan, Vol. II, Section 4.3.11) to be conducted in a horizontal borehole with a diameter equal to that planned for canister emplacement holes in the repository (30 inches). Data from this test is to provide for continued development and preliminary validation of canister scale numerical models.

STATUS: Pending. To be closed upon issuance of ES Test Plan.

ITEM REFERENCE: SECTION 14.3.1, PAGE 14.3-73, PARAGRAPH 1

NRC COMMENT

WILL TESTS TO DETERMINE EFFECT OF HEATED WATER ON JOINTS AND INFILLING MATERIAL BE CONDUCTED IN ES-II?

STATUS

AGREED

BWIP RESPONSE

- WORK ELEMENT R.1.71 WILL BE REVISED TO STATE TESTS WILL BE CONDUCTED
- ES TEST PLAN WILL PROVIDE DETAILS

ITEM REFERENCE: Section 14.3.1, page 14.3-73, paragraph 1

Behavior of saturated rock will be factored into the determination of drying and saturation effects. The effect of heated water on the joints and infilling material with time and the relation of these effects to rockmass behavior will be analyzed. Hydraulic head in the near field prior to and during construction will be measured. The effect of heated water on the integrity of the structural support systems with time will be determined.

NRC COMMENT: "The effect of heated water on the joints...on the integrity of the structural support systems with time will be determined."/9 -- "Will these tests be conducted in the ES-II facility?"

STATUS: Agreed

BWIP RESPONSE: Plans for work element R.1.71 will be revised to confirm that these tests will be conducted in the ES-II facility. The referenced ES test plan will provide test details.

ITEM REFERENCE: SECTION 14.3.1, PAGE 14.3-73, PARAGRAPH 1

BWIP RESPONSE 11/83

TEMPERATURE/MOISTURE EFFECT ON JOINT AND INFILLING MECHANICAL BEHAVIOR TO BE DETERMINED IN LAB TESTS WITH SUPPORTING EVIDENCE POSSIBLE FROM HEATER TEST IN ES II.

TEMPERATURE EFFECT ON JOINT PERMEABILITY TO BE MEASURED IN HEATER TEST IN ES II.

PLANS FOR TEMPERATURE/MOISTURE EFFECT ON SUPPORT SYSTEM STILL IN PROGRESS (CONTRACT WITH D'APPOLONIA CONSULTING ENGINEERS, INC.).

STATUS

PENDING -- TO BE CLOSED UPON ISSUANCE OF THE SCP.

ITEM REFERENCE: Section 14.3.1, page 14.3-73, paragraph 1

BWIP RESPONSE 11-29-83: The most detailed information on the performance of saturated joints at elevated temperatures is to be obtained from controlled testing in the laboratory using samples from the ES facility. More information on such laboratory activities will be included in the SCP. The heater test in Phase ~~II~~ of the ES program (see ES Test Plan, Vol. II, Section 4.3.11) may yield some information on how high temperatures affect joint behavior, but only in an indirect fashion.

Laboratory examination and testing on joint infilling material from the region around the heater test will help establish how this material responds to long periods in a heated enviornment, and consequently, how stability and isolation potential may be affected. Hydrologic property measurements to be conducted in boreholes as part of the heater test (see ES Test Plan, Vol. II, Section 4.3.11.4.8) are to provide direct evidence of any affects of the heating process.

Details of the procedure for investigating the effects of elevated temperatures on the support system have not yet been formulated. As a minimum, the heated room test proposed for a period following ES-II (see ES Test Plan, Vol. II, Section 4.1.3.10) will serve as a vehicle to examine such effects. A contract has been let to D'Appolonia Consulting Engineers Inc. to examine support system requirements in the repository environment.

RECOMMENDED STATUS: Pending. To be closed upon issuance of the Site Characterization Plan.

ITEM REFERENCE: SECTION 14.4, PAGE 14.4-2, FIGURE 14.2

NRC COMMENT

HOW WILL RESULTS FROM ES BE EXTRAPOLATED TO RRL TO RESOLVE R.I.A. AND R.I.D?

STATUS

AGREED

BWIP RESPONSE

- FIGURE 14-2 WILL BE REVISED TO SHOW HOW ES TESTING RESOLVES ISSUES
- WORK ELEMENT R.1.13.B WILL DESCRIBE METHODOLOGY

ITEM REFERENCE: Section 14.4, page 14.4-2, Figure 14-2

NRC COMMENT: "The logic diagram for geoengineering and repository design that all major issues (R.I.A, R.1.B, R.1.C, and R.1.D) will be resolved from ES-I and ES-II testing."/18 -- "It is not clear how results from ES-I and ES-II testing will be extrapolated to the RRL to resovle issues R.1.A and R.1.D."

STATUS: Agreed

BWIP RESPONSE: The logic diagram, Figure 14-2, will be revised to show those elements of the ES-I and ES-II testing which are used to resolve the relevant issues. Plans for work element R.1.13.B will describe methodology for use of test data to resolve all relevant issues.

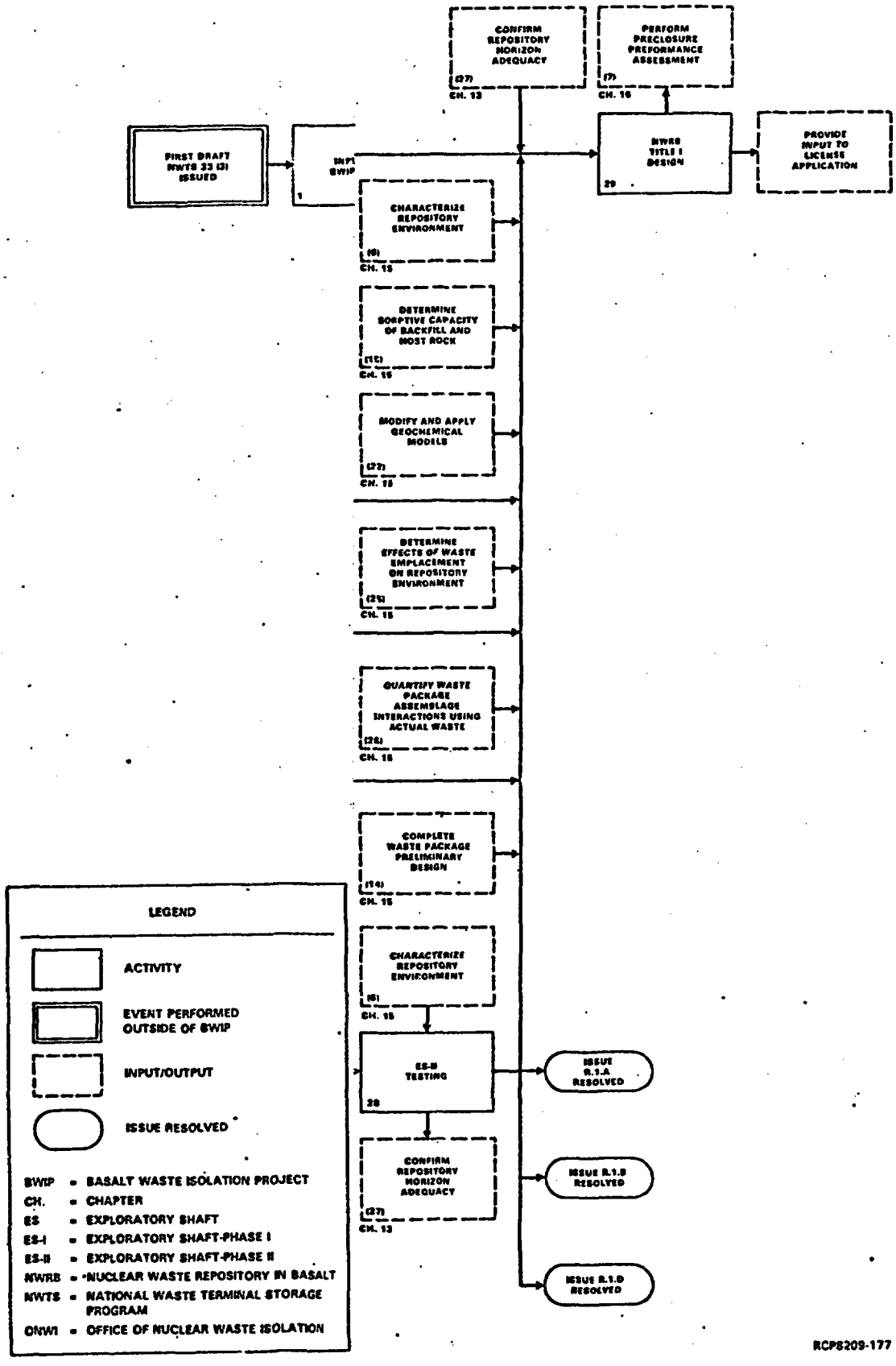


FIGURE 14-2. Logic Diagram for Geoengineering and Repository Design.

ITEM REFERENCE: SECTION 17.3, PAGE 17.3-3, FIGURE 17-9

NRC COMMENT

EXPLAIN HOW ES-II TESTING WILL BE INTEGRATED WITH TESTING IN BOREHOLES RRL-2, -6, AND -14 TO RESOLVE R.I.A AND R.I.D.

STATUS

AGREED

BWIP RESPONSE

PLANS FOR ISSUE RESOLUTION WILL DESCRIBE METHODOLOGY

ITEM REFERENCE: Section 17.3, page 17.3-3, Figure 17-9

NRC COMMENT: "Results of ES-II testing will resolve issues R.1.A, R.1.B, and R.1.D, as presented in the schedule, Figure 17.9."/10 -- "The manner in which ES-II testing will be intergrated with testing in boreholes RRL-2, RRL-6, and RRL-14 to resolve R.1.A and R.1.D is not clear."

STATUS: Agreed

BWIP RESPONSE: Plans for resolution of these issues will describe methodology for integration ES-II testing with testing in boreholes RRL-2, -6, and -14.

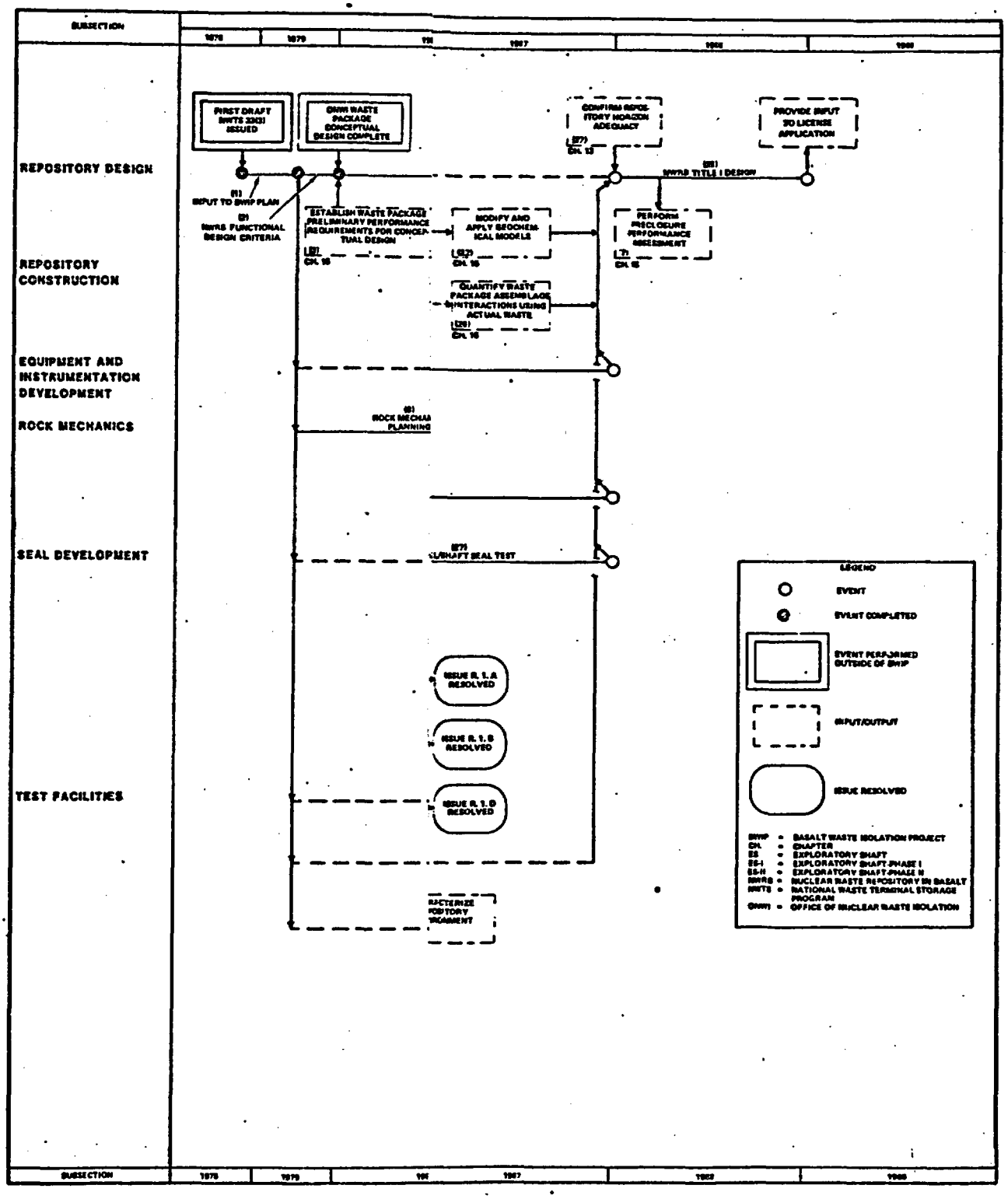


FIGURE 17-9. Schedule for Resolution of Geoengineering and Repository Design Issues.

METHODS OF ESTIMATING ROCK MASS PROPERTIES THROUGHOUT RRL

ROCK MASS PROPERTY	....WILL BE ESTIMATED FROM	....USING FOLLOWING METHODOLOGY
DEFORMATION MODULUS (E)	GEOMECHANICS LOGGING DATA - GEOLOGIC INFORMATION - UNIAXIAL STRENGTH - IN SITU STRESS	$E = 2(RMR) - 100$ BIENIAWSKI, 1979 $E = F(Q)$ FROM CHART BY BARTON ET AL, 1980
	WAVE VELOCITY - LAB - GEOPHYSICAL LOGGING	$E/E_{DYNAMIC}$ USING RATIOS FROM - NSTF TESTING - ES TESTING - LITERATURE
	E_{LAB}, K_N (JOINT STIFFNESS), JOINT SPACING	E/E_{LAB} USING RATIO VALUES - FROM NSTF/ES TESTING - EMPIRICAL RELATIONSHIPS; GOODMAN & DUNCAN, 1971 KULHAWY, 1978

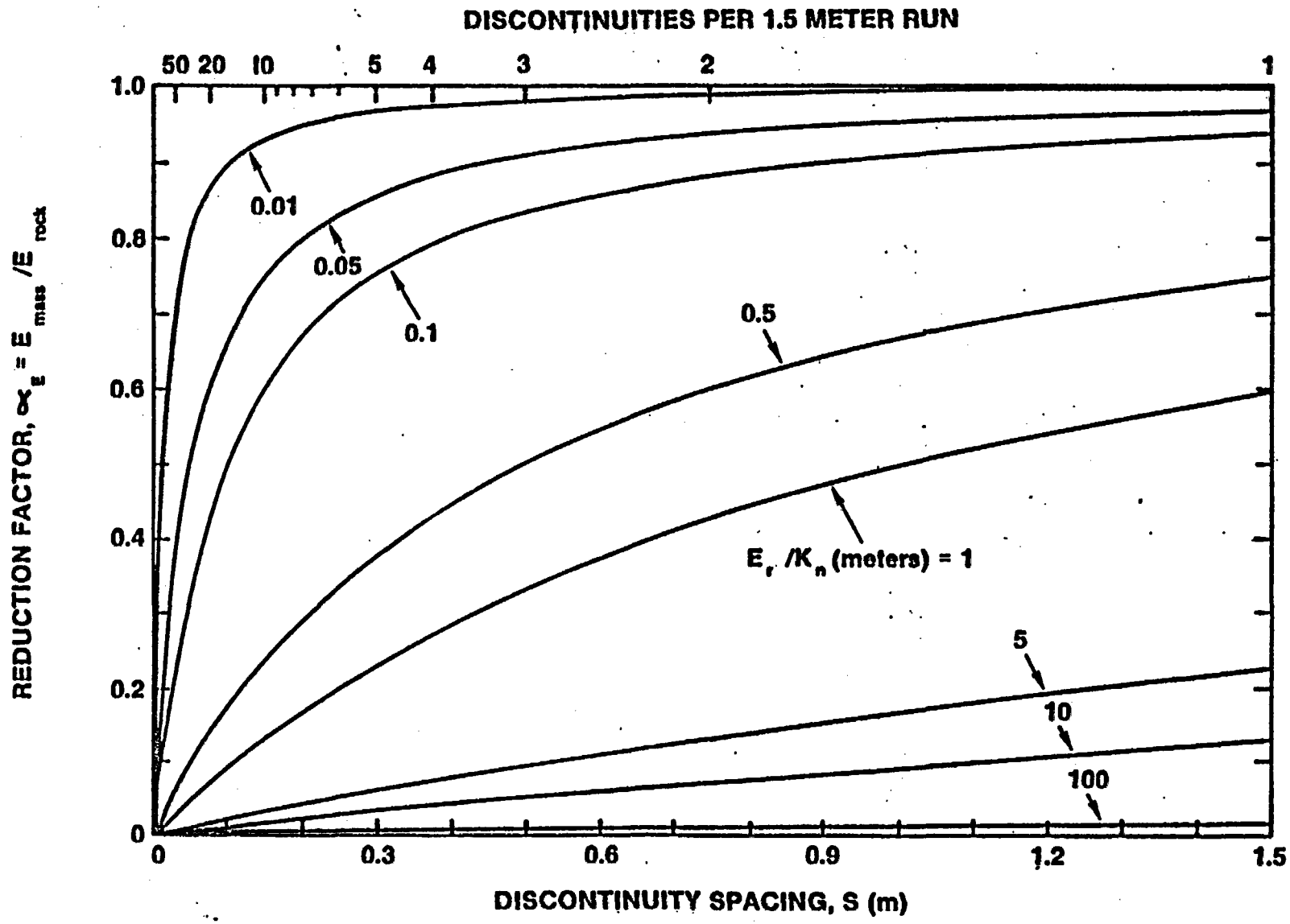
METHODS OF ESTIMATING ROCK MASS PROPERTIES THROUGHOUT RRL

ROCK MASS PROPERTY	....WILL BE ESTIMATED FROM	....USING FOLLOWING METHODOLOGY
STRENGTH (FAILURE CRITERIA)	LAB MECHANICAL PROPERTIES (INTACT, JOINTS) GEOMECHANICS LOGGING DATA	EMPIRICAL FAILURE CRITERIA, HOEK AND BROWN, 1980
	LAB JOINT PROPERTIES GEOLOGIC INFORMATION	LARGE-SCALE JOINT STRENGTH BY EMPIRICAL METHOD OF BARTON & CHOUBEY, 1977 BANDIS ET AL, 1981
	LAB MECHANICAL PROPERTIES (INTACT, JOINTS) GEOMECHANICS LOGGING DATA	DISCRETE BLOCK NUMERICAL MODELING CUNDALL AND HART, 1983

METHODS OF ESTIMATING ROCK MASS PROPERTIES THROUGHOUT RRL

ROCK MASS PROPERTY	....WILL BE ESTIMATED FROM	....USING FOLLOWING METHODOLOGY
THERMAL CONDUCTIVITY (K)	K_{LAB}, GEOLOGIC INFORMATION	K/K_{LAB} USING RATIOS FROM - NSTF TESTING - ES TESTING - LITERATURE
THERMAL EXPANSION COEFFICIENT (α)	α_{LAB}, GEOLOGIC INFORMATION	α/α_{LAB} USING RATIOS FROM - NSTF TESTING - ES TESTING - LITERATURE

Modulus Reduction Factor vs. Discontinuity Spacing



(KULHAWY, 1978)

2K8311-5.4

ITEM REFERENCE: SECTION 14.4, PAGE 14.4-2, FIGURE 14-2

BWIP RESPONSE 11/83

ISSUE R.1.A (MAINTAIN STABILITY AND ISOLATION) RESOLVED IN THE FOLLOWING SEQUENCE:

1. ES TESTS TO PROVIDE EVIDENCE INDICATING WHETHER STABILITY AND ISOLATION CAPABILITY CAN BE MAINTAINED AT THE ES LOCATION.
2. ES TESTS ALSO PROVIDE DATA TO DEVELOP/VALIDATE NUMERICAL MODELS FOR PREDICTING GENERALIZED BASALT GEOMECHANICS AND HYDROLOGIC BEHAVIOR.
3. RANGE OF ROCK MASS GEOLOGIC, GEOMECHANICS AND HYDROLOGIC PROPERTIES THROUGHOUT RRL ESTIMATED FROM LOGGING AND TESTING USING VERITICAL (RRL) AND LONG HORIZONTAL (ES) BOREHOLES.
4. RANGE OF PROPERTIES USED AS INPUT TO NUMERICAL MODELS TO PREDICT STABILITY AND ISOLATION PERFORMANCE THROUGHOUT RRL.

STATUS

PENDING -- TO BE CLOSED UPON ISSUANCE OF THE SCP.

ITEM REFERENCE: Section 14.4, page 14.4-2, Figure 14-2

BWIP RESPONSE 11-29-83: At the completion of ES testing, it is anticipated that a sufficient body of experimental evidence will be assembled to determine whether stable openings at the ES location can be maintained at ambient and elevated temperatures and whether rock mass hydrologic properties in the vicinity of ES openings are adversely affected by thermal loading. Concurrently, the ES tests and observations will be providing for the development and partial validation of numerical models to predict the behavior of jointed basalt. While these models are being developed and validated based on information from only the limited volume of rock encompassing the ES facility, the physical principles represented in the model are applicable to a general class of rock mass behavior. Hence, a wider range of rock mass parameters than is expected to be encountered in the ES facility can be accommodated. Therefore, the models are expected to be suitable for predicting rock mass behavior throughout the entire RRL region, provided that geologic and geomechanics input parameters are accurately defined for that region.

The process of defining geologic and geomechanics parameters for the RRL will rely heavily on empirical relationships between data obtained from boreholes around the site and rock mass properties measured in the ES and NSTF. The range and variability of rock mass physical, mechanical, thermal, and thermomechanical parameters throughout the RRL will be estimated using the following data:

- Laboratory tests on core samples from vertical boreholes in and near the RRL and from 300 m (1000 ft) long horizontal boreholes drilled from the ES facility.
- Geologic logging of vertical and horizontal boreholes including the determination of geomechanics classification indices (RMR, etc.)
- Geophysical logging of vertical and horizontal boreholes.

In most cases, extrapolation from laboratory test data to estimated field parameters will be made using geologic logging/mapping information, laboratory-to-field relationships established from NSTF and ES testing programs and appropriate data for other rock types in the literature. Some examples of the extrapolation and/or estimation methodologies are given in Table 1.

Variation of in situ stress magnitudes and directions within the RRL will be estimated from hydraulic fracturing tests conducted from the ground surface in vertical boreholes around the site and from the ES facility in the 300 m (1000 ft) long horizontal boreholes.

With ranges of input parameters defined from activities described above, the numerical models will then be used to determine if stability and isolation capability can be maintained throughout the RRL. Resolution of Issue R.1.A can thus be achieved.

TABLE 1. Methodology for Assessing Spatial Variation of Rock Mass Parameters within the RRL.

ROCK MASS PROPERTY:	---will be estimated from:	---using the following methodology:
Deformation Modulus (E)	Geomechanics logging data (geologic data, uniaxial compressive strength, tensile strength, in situ stress)	Estimate rock mass modulus from empirical classification relationships involving RMR (Bieniawski, 1979) and Q (Barton and others, 1974) modified if necessary based on results of plate-bearing, large flat jack and room-scale enlargement/mine-by tests in the ES and results of plate-bearing, large flat jack and triaxial block tests in the NSTF.
	Wave velocity (geophysical logging, laboratory testing)	Estimate static rock mass modulus using $E_{static}/E_{Dynamic}$ ratio, with $E_{Dynamic}$ determined from wave velocities measured during geophysical logging and ratios calculated from ES tests, NSTF tests, and case histories in jointed, hard rocks.
	E_{Lab}, K_N (joint normal stiffness), joint spacing	Estimate rock mass modulus from empirical expressions involving laboratory determined properties and joint spacing data from borehole/core logging activities as recommended by Goodman and Duncan (1971) or with RQD values as recommended by Kulhawy (1978) and others.

TABLE 1. Methodology for Assessing Spatial Variation of Rock Mass Parameters within the RRL.

(continued)

ROCK MASS PROPERTY:	---will be estimated from:	---using the following methodology:
Strength (Failure Criteria)	Laboratory uniaxial/triaxial compressive and joint shear strength; geomechanics logging data	Estimate rock mass failure criteria using empirical methods such as recommended by Hoek and Brown (1980).
	Laboratory uniaxial compressive and joint shear strengths; core logging data	Estimate large-scale joint strength using empirical extrapolation methods such as recommended by Barton and Choubey (1977) and Bandis and others (1981).
	Laboratory uniaxial/triaxial compressive and joint shear strengths; geomechanics logging data	Estimate jointed rock mass failure criteria using discrete block numerical modeling such as formulated by Cundall and Hart (1983)
Thermal Conductivity (K)	Laboratory thermal conductivity	Estimate rock mass thermal conductivity using $\frac{K_{Field}}{K_{Lab}}$ ratios established from NSTF testing (including heater tests FS-1 and FS-2 and heated block test), from ES testing (heater test) and from any appropriate case histories in jointed rock.
Thermal Expansion Coefficient (α)	Laboratory thermal expansion coefficient	Estimate rock mass thermal expansion coefficient using $\alpha_{Field}/\alpha_{Lab}$ ratios established from NSTF testing (including heater tests FS-1 and FS-2 and heated block test), ES testing (including heater test) and appropriate case histories in other rock types. Future laboratory tests on candidate repository horizon samples includes large-scale heated triaxial test on jointed sample of 0.5 m dimension or larger.

RECOMMENDED STATUS: Pending. To be closed upon issuance of the Site Characterization Plan.

REFERENCES

1. Bandis, S, Clunsden, A. and Barton, N. (1981). "Experimental Studies of Scale Effects on the Shear Behavior of Rock Joints," Int. J. Rock Mech. Min. Sci. and Geomech. Abstr., Vol. 18, pp. 1-21.

2. Barton, N. and Chouley, V. (1977). "The Shear Strength of Rock Joints in Theory and Practice," Rock Mechanics, Vol. 10, pp. 1-54.

3. Barton, N, Lien, R. and Lund, J. (1974). "Engineering Classification of Rock Masses for the Design of Tunnel Support," Rock Mechanics, Vol. 6, pp. 189-236.

4. Bieniawski, Z. T. (1979). "The Geomechanics Classification in Rock Engineering Applications," Proc., 4th Congr. Int. Soc. Rock Mech., Montreux, Switzerland.

5. Goodman, R. E. and Duncan, J. M. (1971). "The Role of Structure and Solid Mechanics in the Design of Surface and Underground Excavation in Rock," Proc., Conf. on Structure, Solid Mechanics and Engineering Design, Part 2, Paper 105, John Wiley and Sons, Inc., NY, p. 1379.

6. Hoek, E. and Brown, E. T. (1980). "Empirical Strength Criterion for Rock Masses," J. of Geotech. Division, ASCE, Vol. 106, GT 9, pp. 1013-1033.

7. Kulhawy, F. H. (1978). "Geomechanical Model for Rock Foundation Settlement," J. of Geotech. Eng. Division, ASCE, Vol. 104, GT 2, pp. 211-227.

ITEM REFERENCE: SECTION 17.2.6, PAGE 17.2-26, PARAGRAPH 3

NRC COMMENT

LARGE SCALE ROCK MASS TESTING IS IMPORTANT TO CHARACTERIZE COUPLED THERMO-MECHANICAL/HYDROLOGICAL BEHAVIOR

STATUS

AGREED

BWIP RESPONSE

ES TEST PLAN WILL PROVIDE INFORMATION ON LARGE SCALE ROCK MASS TESTING AND BE REFERENCED IN SCP

ITEM REFERENCE: Section 17.2.6, pge 17.2-26, paragraph 3

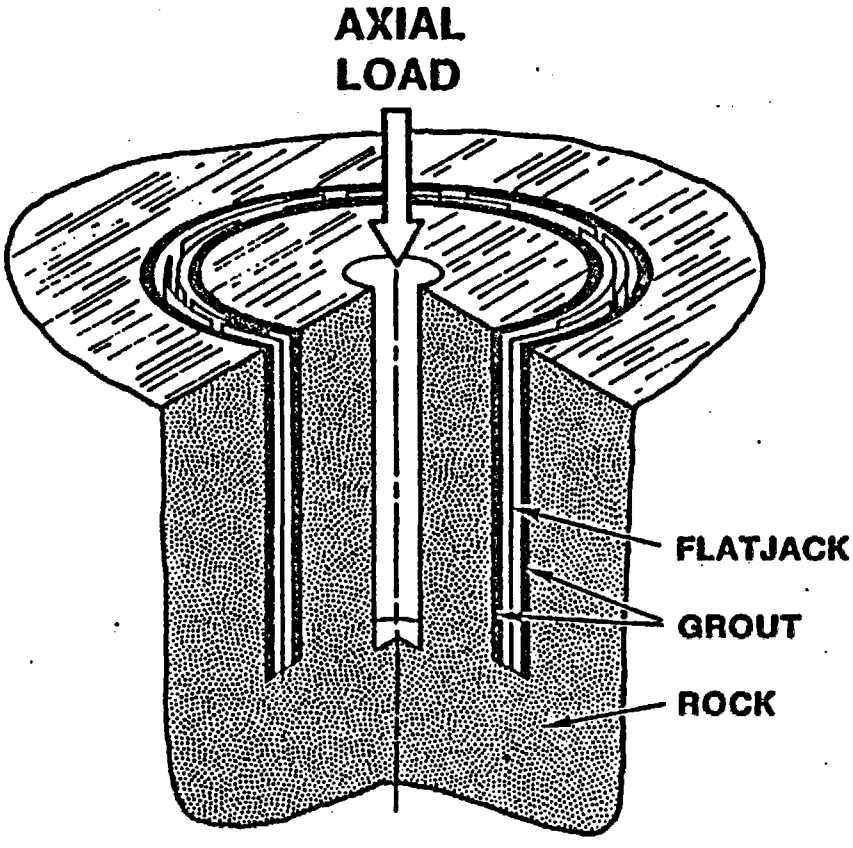
Tests may be conducted, if required, to establish the rock-mass strength. No specific test has been identified for this purpose but ongoing testing of equipment, procedures, and techniques at the Near-Surface Test Facility could be used to develop the testing techniques. The testing possibilities range from observational techniques comparing conditions underground to properties obtained from core samples, to the performance of a sophisticated test configured so that the failure planes will include both natural joints and intact rock. The key parameters expected to be obtained from the geotechnical characterization are presented in Table 17-8.

NRC COMMENT: "Tests may be conducted, if required, to establish the rock-mass strength. No sepcific test has been ... could be used to develop the testing techniques."/9 -- "Large-scale rock mass testing is important to characterize rock mass behavior especially coupled thermo-mechanical/hydrological behavior."

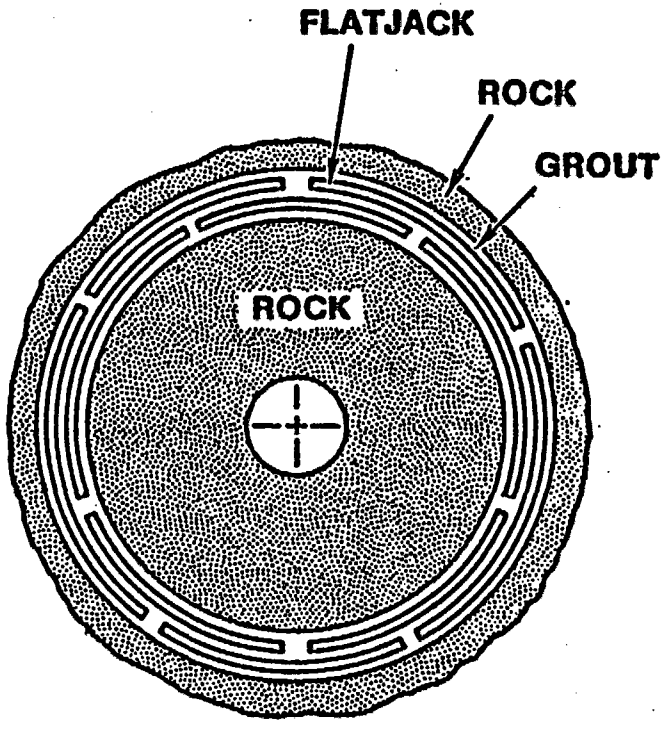
STATUS: Agreed

BWIP RESPONSE: Information on large-scale rock mass testing will be included in the Exploratory Shaft Test Plan and will be referenced in the SCP.

In Situ Triaxial Strength Test



CUT AWAY VIEW



PLAN VIEW

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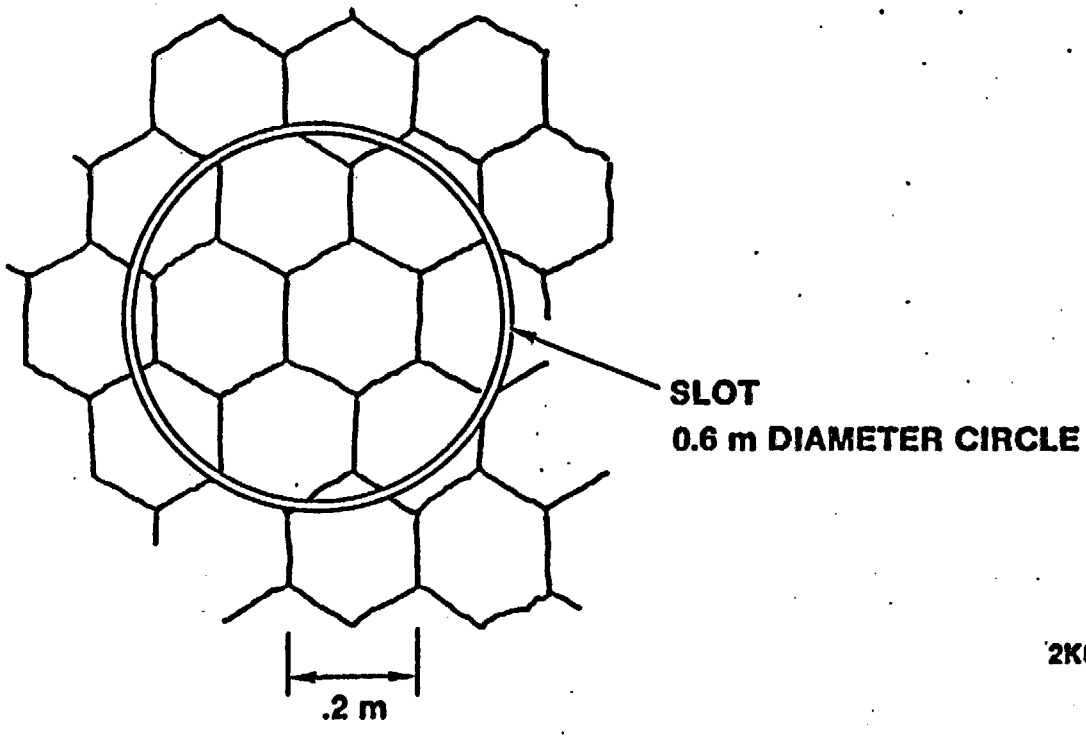
In Situ Triaxial Test:
Sample Size Versus Basalt Structure

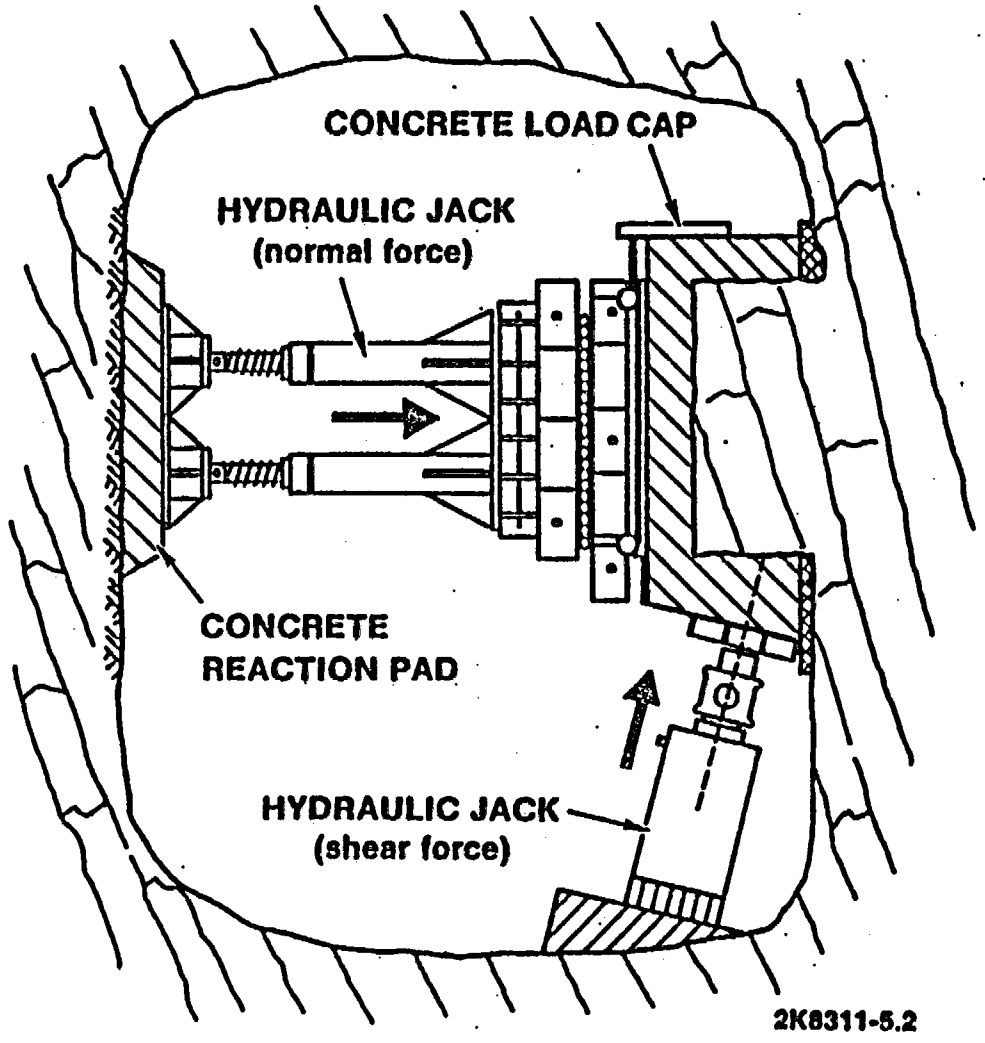


2K8311-5.7

REQUIRED FAILURE LOAD FOR IN SITU TRIAXIAL TEST

	CONFINING STRESS (MPA)	FAILURE LOAD (TONS)	
LOW STRENGTH	0	590	
ESTIMATE	3	1,400	
			0.6M DIAMETER
HIGH STRENGTH	0	2,130	
ESTIMATE	3	5,370	
LOW STRENGTH	0	1,630	
ESTIMATE	3	3,880	
			1.0M DIAMETER
HIGH STRENGTH	0	5,910	
ESTIMATE	3	14,910	

Block Shear Test



DISCRETE BLOCK NUMERICAL MODELING - EXAMPLE CASE
(CUNDALL ET AL, 1978)

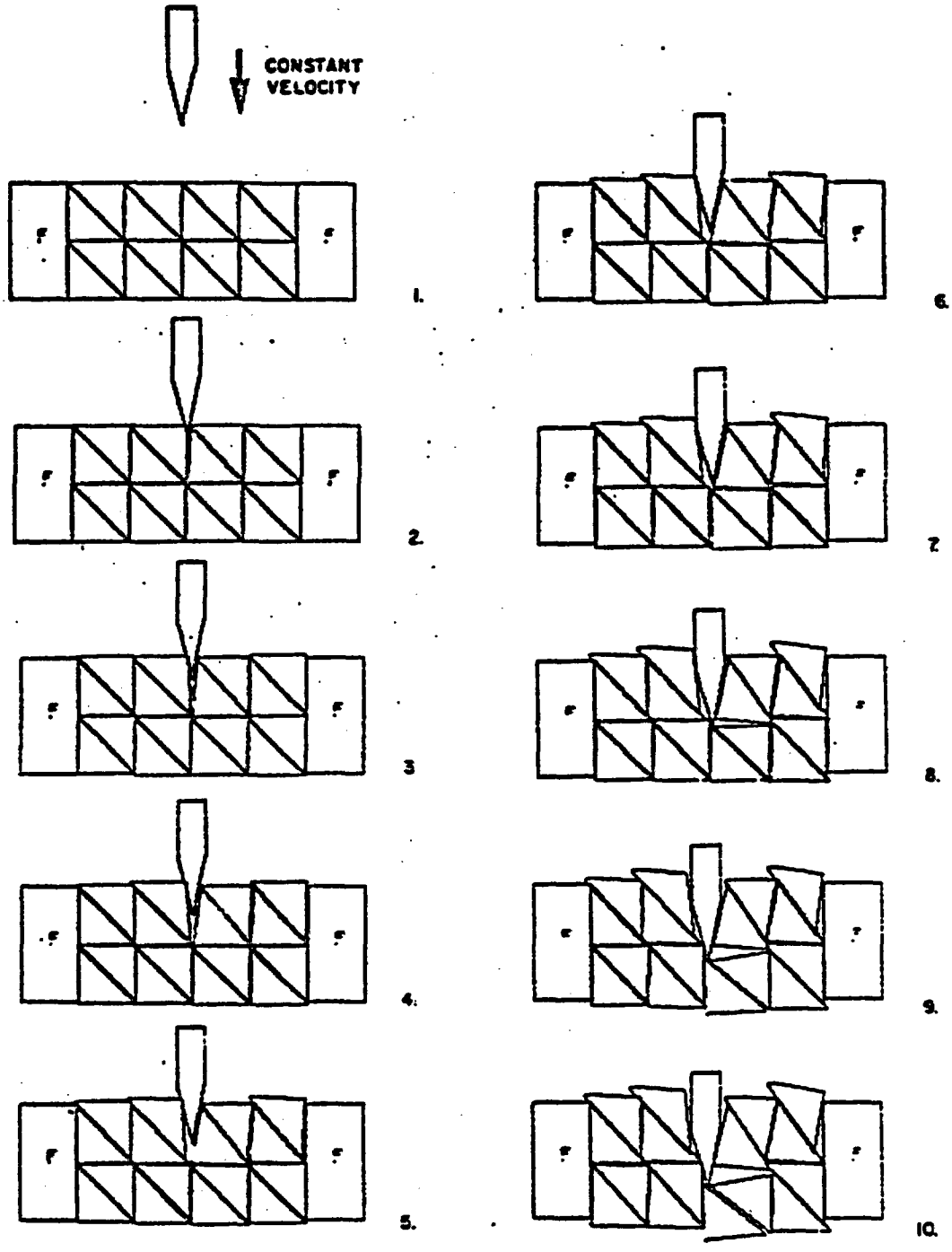


FIG. 3.5 PENETRATION TEST WITH PLASTIC FLOW
AND JOINT SLIP - PROGRAM 'SDEM

ITEM REFERENCE: SECTION 17.2.6, PAGE 17.2-26, PARAGRAPH 3

BWIP RESPONSE 11/83

VERY HIGH LOADS REQUIRED TO FAIL REPRESENTATIVE SIZE SAMPLES SEEM TO MAKE IN SITU STRENGTH TEST IMPRACTICAL FOR BASALT.

ALTERNATIVE APPROACH TO BE USED, INCLUDING:

1. LABORATORY TESTING
2. EMPIRICAL FAILURE CRITERIA
3. DISCRETE BLOCK NUMERICAL MODELING
4. BACK-ANALYSIS FROM OPENING STABILITY OBSERVATIONS IN THE ES

STATUS

PENDING -- TO BE CLOSED UPON ISSUANCE OF THE ES TEST PLAN.

ITEM REFERENCE: Section 17.2.6, page 17.2-26, paragraph 3

BWIP RESPONSE 11-29-83: At the time of the completion of the current version of the ES Test Plan, the BWIP had taken the position that large-scale strength tests in basalt were impractical and that a multi-faceted approach to the estimation of rock mass strength would be adopted (see ES Test Plan. Vol. II, Section 4.1.3.6). Large-scale tests were judged to be impractical because of the extremely high load levels required to produce failure in compression. For example, if a large core barrel were used to form a cylindrical sample of marginally acceptable dimensions (0.6 m in diameter) in the floor or wall of one of the ES drifts, an axial load of at least 900 tons (8 MN) would be required to fail the sample, assuming a lower bound rock mass failure criteria as presented in Appendix A. Application of a very modest confining stress of 3 MPa using curved flat jacks (a triaxial test configuration) would increase the required failure load to at least 1400 tons (12 MN). Even if the required failure load were reduced by preparing samples with columnar joints (weakness planes) oriented at the most critical angle to the axis of loading, constructing an apparatus for testing over a meaningful range of confining stresses would still prove to be a formidable, if not prohibitive, task. Other test configurations of adequate sample size face similar problems.

Assumptions for the above analysis are presented in Appendix A. The BWIP is continuing to evaluate possible ways in which direct large-scale strength measurement tests can be conducted in basalt.

As an alternative to large-scale testing in situ, the ES Test Plan outlines a program of laboratory testing on intact and jointed samples, numerical modeling using the discrete block formulation being developed by Cundall and Hart (1983) and others, empirical rock mass strength estimates using methodologies recommended by Hoek and Brown (1980) and others, and observations of the stability of openings in the ES facility at ambient and elevated temperatures. The excavation of an opening in highly stressed rock can itself be considered a large-scale rock mass strength test. Applied stresses are those which concentrate around the opening (excavation-induced stresses). Such stresses can be measured directly or inferred based upon measured deformation. If the excavation remains stable, a lower bound strength relationship can be determined. If instability occurs, numerical or analytical methods can be employed to approximate the rock mass strength relationship which must have been applicable at that location in order for failure to have occurred.

RECOMMENDED STATUS: Pending. To be closed upon issuance of the ES Test Plan.

REFERENCES

1. Cundall, P.A. and Hart, R.D. (1983), "Development of Generalized 2-D and 3-D Distinct Element Programs for Modeling Jointed Rock," Final Technical Report, U.S. Army Waterways Experiment Station, Vicksburg, Miss.

2. Hoek E. and Brown, E.T. (1980), "Empirical Strength Criterion for Rock Masses, "J. Geotechnical Eng. Div., ASCE, Vol. 106, No. GT9, pp. 1013-1035.

APPENDIX A

Estimates of required failure loads cited in the preceding response were made assuming a basalt failure criteria as follows:

$$\sigma_{1n} = \sigma_{3n} + \sqrt{1.7\,\sigma_{3n} + 0.004}$$

where

$$\sigma_{1n} = \sigma_1/\sigma_c$$

$$\sigma_{3n} = \sigma_3/\sigma_c$$

σ_c = 292 MPa (mean uniaxial compressive strength of Cohassett flow entablature)

This expression represents the failure criteria suggested by Hoek and Brown (1980) for "fine grained polymineralic igneous crystalline rocks" in a "good quality rock mass" with typical rock mass classification system ratings of Q = 10 and RMR = 65. This is thought to be nearly a lower bound estimate for the Cohassett flow at the RRL, primarily because the sinuous and highly interlocking nature of most basalt jointing is not accounted for in the estimate.

CONSTRUCTIBILITY

R. J. BIELEFELD

ITEM REFERENCE: SECTION 14.4, PAGE 14.4-8, PARAGRAPH 3

NRC COMMENT

USE ALL PORTHOLES TO TEST GROUT EFFECTIVENESS

STATUS

AGREED

BWIP RESPONSE

- SCP WILL STIPULATE CHECK OF GROUT SEAL IN PORTHOLE TESTING
- ES TEST PLAN WILL PROVIDE DETAILS

ITEM REFERENCE: Section 14.4, page 14.4-8, paragraph 3

Shaft Casing Seal Verification

Porthole testing will be conducted at the candidate repository horizons to determine the effectiveness of the grout that seals the space between the shaft casing and the surrounding host rock to isolate the various aquifers from each other and from the candidate repository horizons.

NRC COMMENT: "Porthole testing will be conducted at the...to isolate the various aquifers from each other and from the candidate repository horizons."/18 -- "All portholes should be used for testing the effectiveness of the shaft grout."

STATUS: Agreed

BWIP RESPONSE: Section 14.4 will stipulate that all porthole tests will start with check of grout seal. The ES test plan will provide test details.

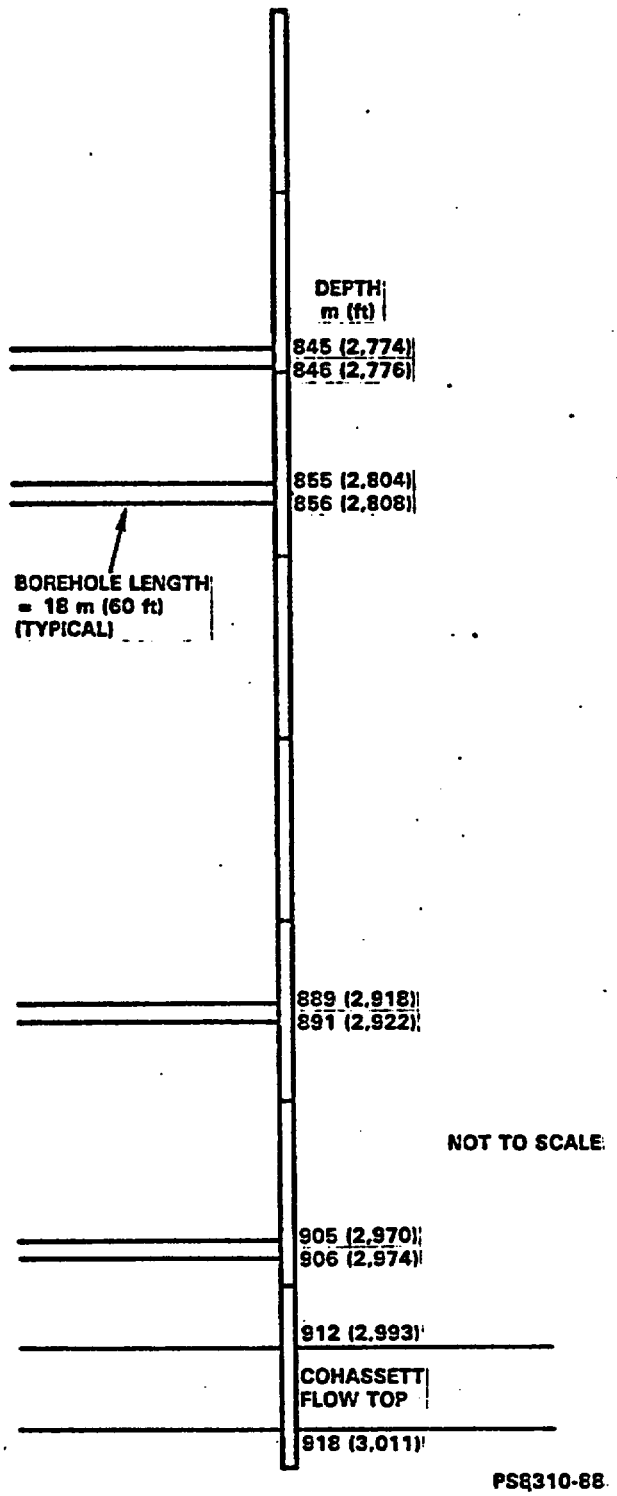


FIGURE 5-12. Seal Testing Porthole Locations.

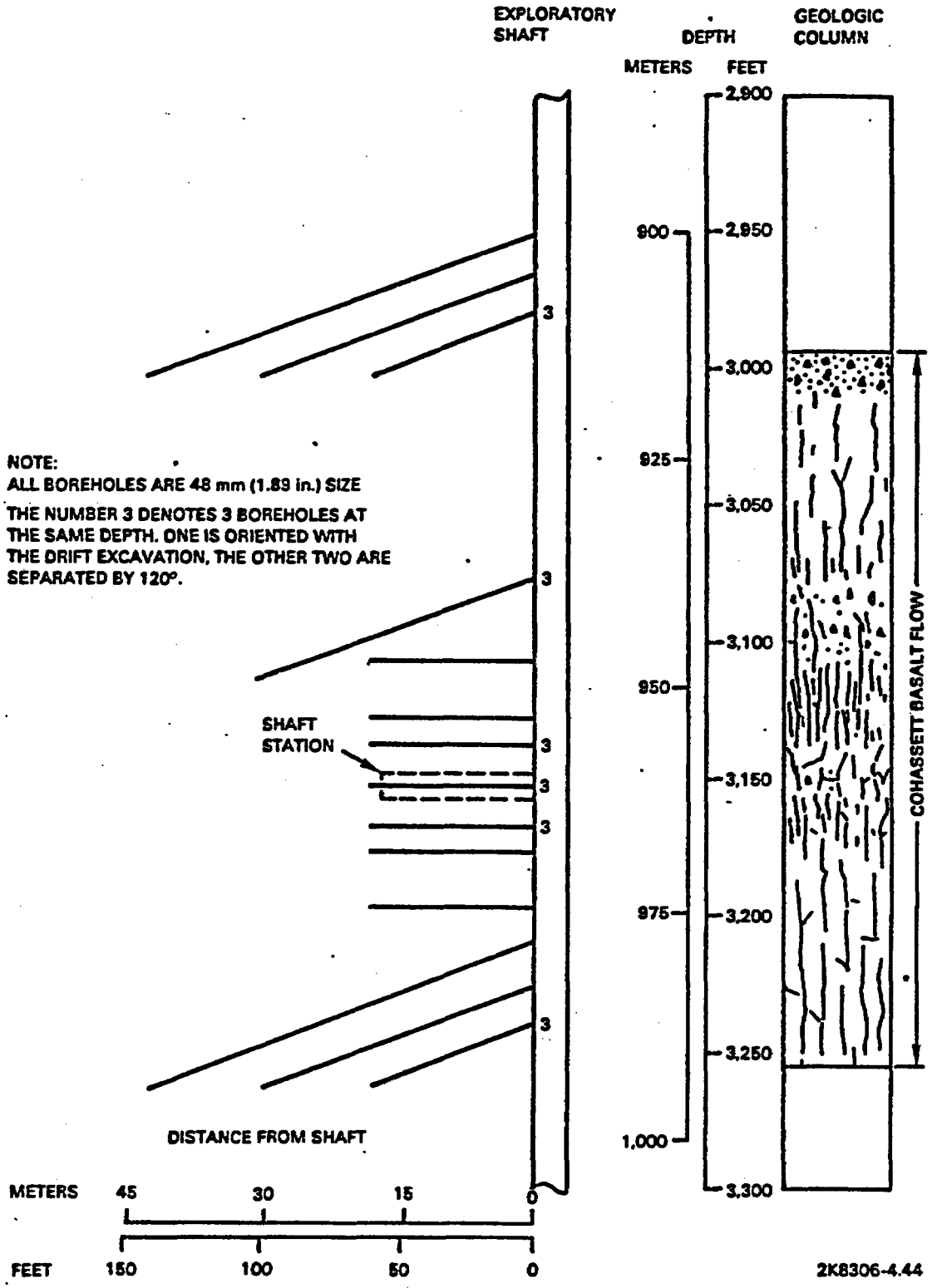


FIGURE 5-13. Hydrologic Testing Porthole Locations.

ITEM REFERENCE: SECTION 14.4, PAGE 14.4-8, PARAGRAPH 3

BWIP RESPONSE 11/83

CURRENT ES TEST PLAN: "ALL LATERAL BOREHOLES DRILLED FROM SHAFT PORTHOLES WILL BE TESTED IN A LIKE MANNER FOR SEAL INTEGRITY, SPECIFICALLY SENSITIVE ZONES LIKE THE BREAKOUT HORIZON WILL BE TESTED IN DETAIL."

STATUS

PENDING -- TO BE CLOSED ON ISSUANCE OF ES TEST PLAN

ITEM REFERENCE: SECTION 17.2.3, PAGE 17.2-13, TABLE 17-4

NRC COMMENT

PRESSURE DIFFERENTIAL AND GROUT STRENGTH PROVIDE INSUFFICIENT DATA ON SHAFT SEAL

STATUS

AGREED

BWIP RESPONSE

ES TEST PLAN WILL PROVIDE MORE INFORMATION AND BE REFERENCED IN SCP.

ITEM REFERENCE: Section 17.2.3, page 17.2-13, Table 17-4

TABLE 17-4. Shaft-Seal Verification--Key Results.

Test Program Objective 3 (Phase I): Verify that an exploratory shaft can successfully seal off the groundwater system and evaluate the effects of shaft construction on the surrounding rock at the reference repository location.

Key tests	Key parameters measured	Units	Predicted value	Rationale for consideration of key parameters
GEOLOGIC	Depth of disturbed rock	m (ft)	1 (3)	Isolation: Construction-affected zone must be identified.
HYDROLOGIC	Water inflow	L/s (gal/min)	TBD*	Constructibility: This parameter verifies proper grout placement.
	Pressure differential	MPa (lb/in2)	TBD*	Same as above.
ROCK MECHANICS	Grout strength	MPa (ksi)	21 (3)	Same as above.
CONSTRUCTIBILITY ASSESSMENT--No separate tests				

TBD = To be determined.
*Dependent on safety and design requirements.

NRC COMMENT: "Pressure differential and grout strength."/18 -- "These parameters do not provide sufficient data on the shaft seal."

STATUS: Agreed

BWIP RESPONSE: ES test plan will provide more information and will be referenced in the SCP.

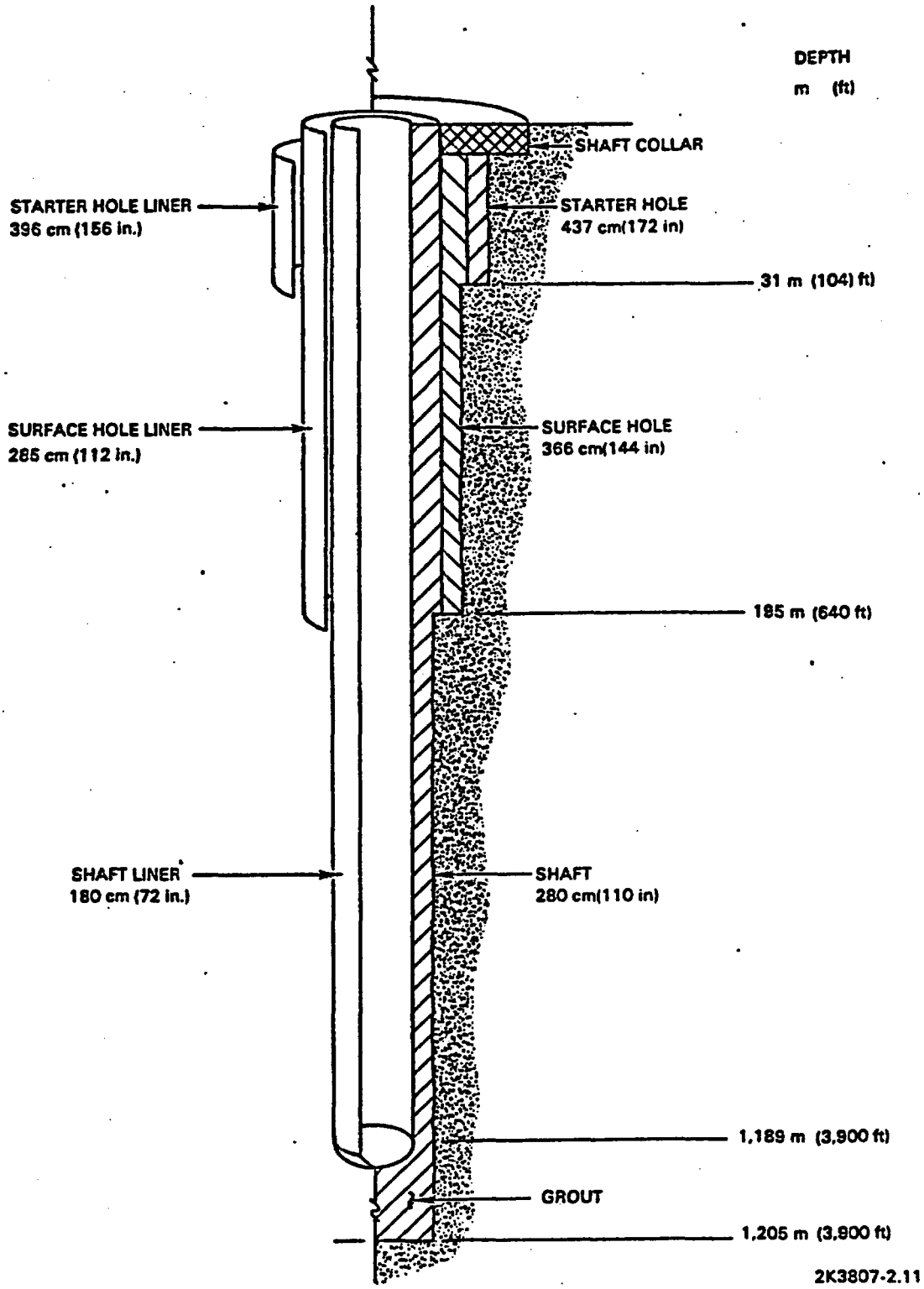


FIGURE 5-5. Shaft Liner System.

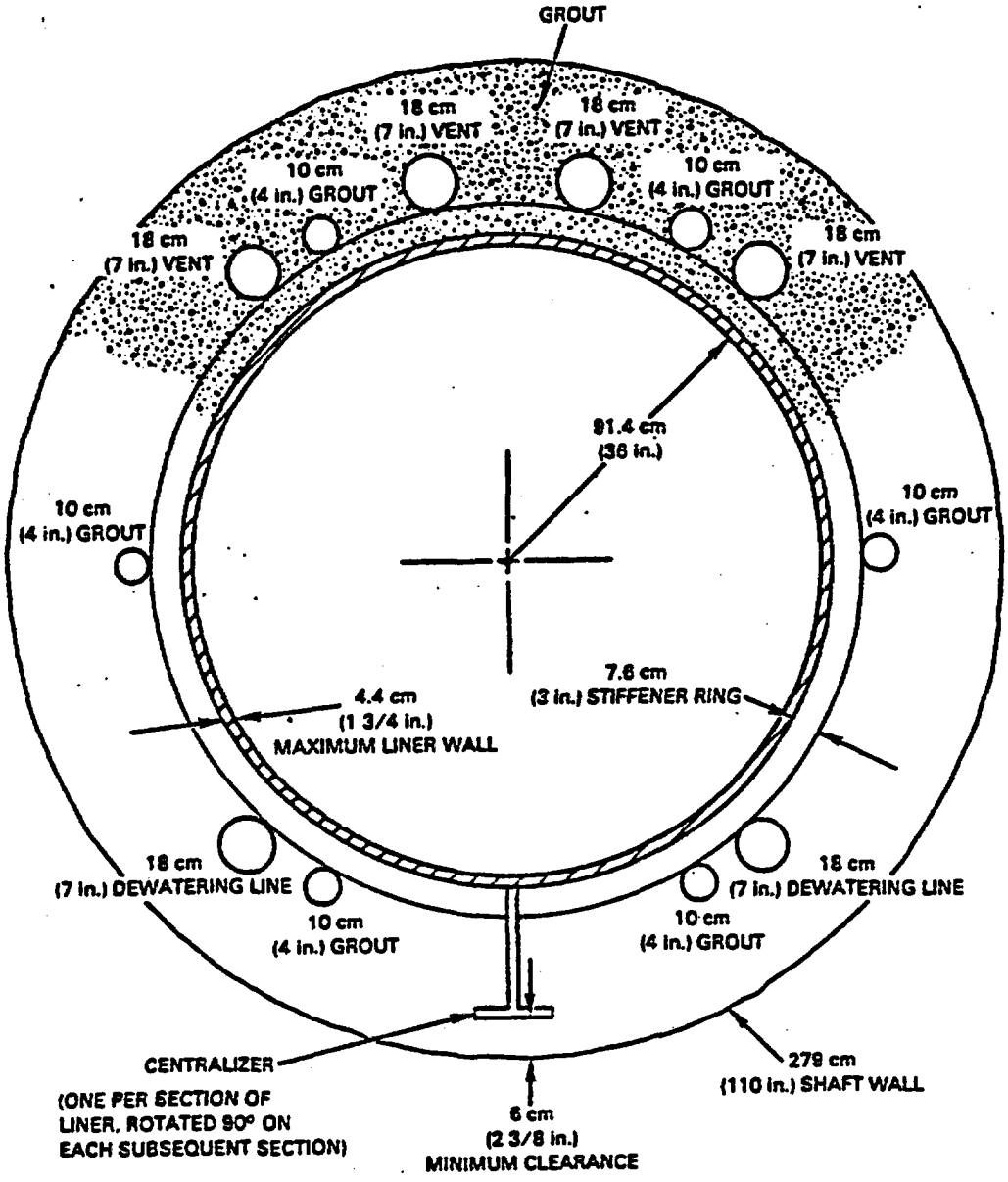


FIGURE 5-7. Shaft Liner Cross Section.

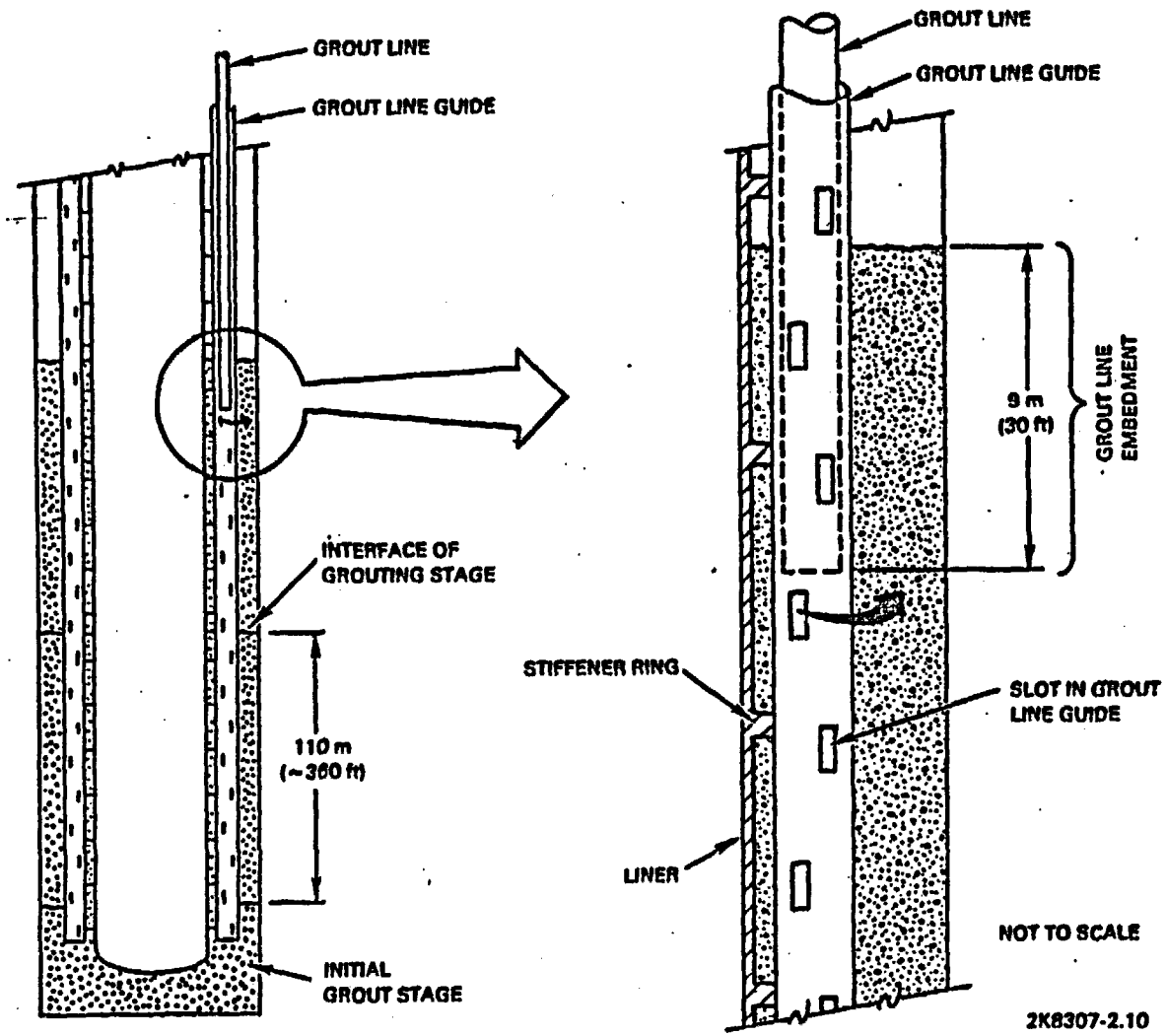


FIGURE 5-8. Shaft Liner Grout Lines and Guides.

ITEM REFERENCE: SECTION 17.2.3, PAGE 17.2-13, TABLE 17-4

BWIP RESPONSE 11/83

THE ES TEST PLAN QUOTES THE SPECIFICATIONS PREPARED BY THE SHAFT CEMENTATION ENGINEER. THE CEMENT WILL ATTAIN 10 MPA (1500 PSI) PRIOR TO SECOND STAGE CEMENTING. THE MAXIMUM CEMENT STRENGTH (DESIGN) IS 24 MPA (3500 PSI). THIS LEVEL WILL BE DETERMINED BY UNIAXIAL STRENGTH TESTS ON THE PORTHOLE CORE REMOVED.

THE GROUTING PRESSURE DIFFERENTIAL WILL BE NEGLIGIBLE SINCE THE LINER WILL BE FILLED WITH WATER DURING THE GROUTING STAGE. SECONDARY GROUTING WILL BE DESIGNED AT THE TIME OF NEED, IF REQUIRED.

STATUS

PENDING -- TO BE CLOSED ON ISSUANCE OF ES TEST PLAN

ITEM REFERENCE: SECTION 10.8, PAGE 10.8-3, PARAGRAPH 4

NRC COMMENT

"THE EFFECT OF THE DISTURBED ... SENSITIVITY ANALYSIS. THE RESULTS OF THESE STUDIES ... AFFECTED BY DISTURBANCE IS REQUIRED."/3 -- "VERY VAGUE AND NONCOMMITAL. ARE LARGE-SCALE FIELD TESTS OPTIONAL?"

STATUS

AGREED

BWIP RESPONSE

SCP WILL BE REVISED TO REFLECT:

- IN SITU ROCK MECHANICAL AND HYDROLOGIC FIELD TESTING WILL BE PERFORMED IN ES TO ACCURATELY CHARACTERIZE DISTURBED ROCK ZONE
- CHARACTERIZATION AND REMEDIAL WORK AT SEAL SITES WILL BE DONE PRIOR TO EMPLACEMENT

ITEM REFERENCE: Section 10.8, page 10.8-3, paragraph 4

Generic seal studies conducted by the National Waste Terminal Storage Program have also revealed (Kelsall et al., 1982) that areas around underground openings and shafts are disturbed by excavation and stress relieving. The disturbed rock zone may provide a preferential pathway for groundwater flow and radionuclide migration. The effect of the disturbed rock zone on repository seal performance will be initially assessed by sensitivity analysis. The results of these studies may determine that a preferred method should be used in underground opening and shaft construction, or that sealing areas affected by disturbance is required.

NRC COMMENT: "The effect of the disturbed ... sensitivity analysis. The results of these studies ... affected by disturbance is required."/3 -- "Very vague and noncommittal. Are large-scale field tests optional?"

STATUS: Agreed

BWIP RESPONSE: Statements will be added to the information presented in the SCR, page 10.8-3, Section 10.8, to reflect the following: Due to inherent difficulty in the analysis, both the extent and nature of rock mass disturbance and of changes in permeability associated with this disturbance, accurate characterization of the disturbed rock zone will require field testing. In situ rock mechanical and hydrologic field testing to be conducted in the Exploratory Shaft Test Facility will enable an accurate characterization of the disturbed rock zone. Rock mass characterization and any necessary remediation at specific seal sites will be done prior to seal emplacement.

ITEM REFERENCE: SECTION 10.8, PAGE 10.8-3, PARAGRAPH 4

BWIP RESPONSE 11/83

THE EXPLORATORY SHAFT TEST PLAN ACKNOWLEDGES THAT A DAMAGED ROCK ZONE IS LIKELY TO BE PRESENT AROUND THE SHAFT. THE MODE OF CONSTRUCTION SELECTED FOR THE EXPLORATORY SHAFT IS PRESUMED TO DO TWO THINGS:

- MINIMIZE THE DEGREE OF DISTURBANCE
- PREVENT IMMEDIATE AND DIRECT OBSERVATION OR RESPONSE TO ANY DEFORMATION

TESTING OF THE POTENTIAL DAMAGED ROCK ZONE AROUND THE SHAFT WILL BE ACCOMPLISHED BY OBSERVATION OF CORE OBTAINED FROM THE LATERAL BOREHOLES, CHANGES IN INFLOW WITH DEPTH OF PENETRATION, AND HYDRAULIC CONDUCTIVITY TESTING IN THE LATERAL BOREHOLES.

SEAL TESTING FOR DECOMMISSIONING IS NOT COVERED IN THE ES TEST PLAN.

STATUS

PENDING -- TO BE CLOSED ON ISSUANCE OF ES TEST PLAN.

ITEM REFERENCE: SECTION 17.2.4, PAGE 17.2-20, PARAGRAPH 4

NRC COMMENT

REVISE TO READ: DEMONSTRATE HYDROGEOLOGIC ISOLATION IN VICINITY OF SHAFT

STATUS

AGREED

BWIP RESPONSE

PROGRAM OBJECTIVE WILL BE SO REVISED

ITEM REFERENCE: Secion 17.2.4, page 17.2-20, paragraph 4

TEST PROGRAM OBJECTIVE 3 (PHASE I)

Verify that an exploratory shaft can successfully seal off the groundwater system and evaluate the effects of shaft construction on the surrounding rock at the reference repository location.

Work Elements

R.1.17.D Develop or adapt instrumentation and test methods to measure the nature and extent of rock-mass disturbance caused by candidate excavation methods and stress redistribution around tunnels and boreholes.

R.1.21.D Develop grouts and grouting techniques that ensure acceptable sealing of the disturbed rock zone.

R.1.28 Assess the effects of adverse conditions on the design and performance of the repository.

NRC COMMENT: Lines 13-25, "Test Program Objective 3 (Phase I)."/3.9 -- "Demonstrate hydrogeologic isolation in vicinity of shaft."

STATUS: Agreed

BWIP RESPONSE: Paragraph will be revised to include demonstration of hydrogeologic isolation in vicinity of shaft.

ITEM REFERENCE: SECTION 17.2.4, PAGE 17.2-20, PARAGRAPH 4

BWIP RESPONSE

NRC CLARIFICATION IS REQUIRED.