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ENCLOSURE

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SUMMARY OF THE NRC/DOE TECHNICAL EXCHANGE ON SCENARIO DEVELOPMENT AND SCREENING AND CONSTRUCTION OF A COMPLEMENTARY CUMULATIVE DISTRIBUTION FUNCTION

April 28-29, 1992
Albuquerque, New Mexico

On April 28-29, 1992, the staff from the Nuclear Regulatory Commission, the U.S. Department of Energy (DOE), the State of Nevada, and DOE program participants conducted a technical exchange to discuss technical and regulatory concerns related to DOE's 1988 Site Characterization Plan (SCP) and the staff's 1989 Site Characterization Analysis (SCA) in the areas related to the methods for developing and screening scenarios in geologic repository performance assessments (PAs) and the construction of a Complementary Cumulative Distribution Function (CCDF). Representatives from affected units of local government also attended the technical exchange. The agenda is attachment 1; attachment 2 is the list of the attendees.

On April 28, 1992, the first presentation was made by N. Eisenberg of the NRC and focused on the concerns raised by the staff during its review of DOE's SCP. These concerns were documented by the staff in its SCA. Seventeen of the 133 NRC SCA comments were related to scenario development. It was noted that of the 17 scenario-related comments, one comment has been closed (no. 107) and sixteen comments still remain open. Attachment 3 is from the SCA and describes NRC's SCA comments. It also contains the staff's evaluation (see Bernero, 1991) of DOE's subsequent response to NRC's SCA (DOE, 1990).

Following the opening presentation, DOE provided an overview (see attachment 4) of how it proposed to discuss technical issues related to NRC's scenario-related SCA comments in the context of the technical exchange agenda (see attachment 1). This correlation, along with a synopsis of the comments, was made by J. Boak of DOE. During the opening presentation, it was also noted that the relationship between performance assessment (and performance allocation) and the SCP was evolving, and DOE identified several reports that have been or are being prepared which document these changes. DOE indicated that because of these changes, a number of the staff's SCA comments may no longer be applicable.

Bernero, R.M., Office of Nuclear Material Safety and Safeguards, Letter to J.W. Bartlett, U.S. Department of Energy [Subject: Status of Site Characterization Plan Open Items], U.S. Nuclear Regulatory Commission, July 31, 1991.

U.S. Department of Energy, "Site Characterization Plan, Yucca Mountain Site, Nevada Research and Development Area, Nevada," Report DOE/RW-0199, December 1988.

U.S. Department of Energy, "Responses to Nuclear Regulatory Commission (NRC) Site Characterization Analysis," Report YMP/90-107, December 1990.

U.S. Nuclear Regulatory Commission, "NRC Staff Site Characterization Analysis of the Department of Energy's Site Characterization Plan, Yucca Mountain Site, Nevada," NUREG-1347, August 1989.

102.2

The third presentation was conducted by F. Bingham of DOE (Sandia National Laboratory (SNL)). It concerned the definition of scenarios and other terms, and how DOE and NRC were applying this concept to their respective PA programs (attachment 5). The discussion that followed served to bring out the differences and similarities in the PA approaches being employed by NRC and DOE in their respective programs.

The fourth topic on the agenda concerned what types of uncertainties there were in the development of scenarios and how they could be treated. DOE first described how it was identifying and treating uncertainties in the development of its PA scenarios. This presentation is summarized in attachment 6 and was made by R. Andrews who represented DOE's Management and Operating Contractor -- TRW Environmental Safety Systems. A comparable discussion was subsequently made by S. Coplan of the NRC who discussed uncertainties in performance assessment and discussed methods for treating the types of uncertainties encountered (attachment 7). During this presentation, Coplan made reference to SECY-91-242, a publicly available Commission paper that describes the staff's views on dealing with the regulatory and technical uncertainties in implementing the U.S. Environmental Protection Agency's radiation protection standards. This presentation lead to considerable discussion of expert judgment and its potential use in weighing alternative conceptual models. (SECY-91-242 was available for distribution at the meeting. However, because it is publicly available in NRC's Public Document Room, SECY-91-242 has not been included as an attachment to this meeting summary.)

The last series of presentations on April 28, 1992, concerned the generation of scenarios. The first presentation was made by G. Barr (SNL) who discussed SNL's approach to the generation of scenarios (attachment 8). It was followed by J. Park of NRC who reviewed with the audience how the NRC staff was evaluating the SNL scenario selection procedure to "Phase 2" of its Iterative Performance Assessment efforts (attachment 9).

On April 29, 1992, the first agenda item concerned the generation and the construction of the CCDF. The lead presentation was made by P. Eslinger (Pacific Northwest Laboratory (PNL)) who described PNL's approach to the construction of the CCDF (attachment 10). Following the DOE presentation, S. Coplan described NRC's alternative approach (i.e., the "three-bucket concept") to the construction of the CCDF, including potential ways that human intrusion scenarios could be treated within that approach (attachment 11). There was considerable discussion of how this approach might apply to a number of hypothetical examples. Given the understanding gained from the presentation, DOE noted that it would attempt some repository analyses to evaluate the so-called "three-bucket" regulatory concept and suggested that another technical exchange be convened within the next two months to discuss any problems that it may find.

U.S. Nuclear Regulatory Commission, "Staff's Approach for Dealing with Uncertainties in Implementing the EPA HLW Standards," SECY-91-242, August 6, 1991.

ENCLOSURE

The second agenda item on April 29, 1992, was an example DOE application of some conditional CCDF's generated from SNL's 1991 total system performance assessment (TSPA). In generating the conditional CCDF's, M. Wilson of SNL described the four conditions modeled during the 1991 Yucca Mountain TSPA: undisturbed, basaltic volcanism, human intrusion, and climate change (attachment 12).

The final presentation was made by DOE (J. Boak) and consisted of a summary review of what DOE thought the current disposition was of the 16 scenario-related SCA comments. This summary was based on the discussions held during the technical exchange. However, in presenting this summary, it was noted by Boak that there had been significant advancement of DOE's PA program since the release of the SCP. As a consequence, much of the information contained in the SCP is no longer current and subject to revision. (The State of Nevada (S. Frishman) noted its concerns that DOE attempt to maintain plans describing its most current site characterization programs.)

The NRC staff acknowledged that as DOE's site characterization programs mature, including those in PA, adjustments are to be expected. The staff noted that 10 CFR Part 60 requires DOE to identify and describe the changes, if any, to its baseline site characterization programs at the time of a license application submittal. Furthermore, the NRC also noted that DOE is expected to disclose what the adjustments are made to its site characterization programs in the SCP semi-annual progress reports, again pursuant to the requirements in 10 CFR Part 60.

In light of the aforementioned discussions, both the NRC and DOE staffs agreed that there was reason to believe that about six of the scenario-related SCA comments (i.e., nos. 106, 108, 110, 112, 113, and 115) could now be closed. DOE is expected to prepare the necessary documentation to reflect closure of these comments. NRC will review the responses to see if DOE has acceptably addressed its concerns.

6.3.92

Michael P. Lee
Repository Licensing and Quality Assurance Project Directorate
Division of High-Level Waste Management
Office of Nuclear Material Safety and Safeguards
Nuclear Regulatory Commission

6/4/92

Priscilla Bunton
Regulatory Integration Branch
Office of Systems and Compliance
Office of Civilian Radioactive Waste Management
U.S. Department of Energy

ATTACHMENT 1

AGENDA FOR THE
NRC/DOE TECHNICAL EXCHANGE ON SCENARIO DEVELOPMENT AND
SCREENING AND CONSTRUCTION OF A COMPLEMENTARY CUMULATIVE
DISTRIBUTION FUNCTION (CCDF)

AGENDA ITEM	DISCUSSION LEAD
April 28, 1972	
° Opening Remarks	DOE, NRC, State
° NRC Performance Assessment Concerns (re: DOE Site Characterization Plan, NRC Site Characterization Analysis (SCA), DOE Response to SCA)	NRC
° Review of Correlation of SCA Comments with Technical Exchange Meeting Agenda	DOE
° Definitions of Scenarios and Conceptual Models	All*
° Types and Treatment of Uncertainties	All*
° Generation of Scenarios	All*
April 29, 1992	
° Generation and Construction of the CCDF**	All*
° Example Application	All*
° Review of Current Status of DOE Response to NRC Concerns	DOE/NRC
° Summary Remarks	All
° Adjourn	

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* DOE lead with comparable discussion by NRC, as appropriate, followed by open discussion.

** Includes discussion of NRC's so-called "three-bucket approach."

ATTACHMENT 2

ATTENDEES AT THE APRIL 28-29, 1992, FOR THE NRC/DOE TECHNICAL EXCHANGE ON SCENARIO DEVELOPMENT AND SCREENING AND CONSTRUCTION OF A COMPLEMENTARY CUMULATIVE DISTRIBUTION FUNCTION

DOE
P. Bunton
T. Bjerstedt
J. Boak
S. Borg

TESS*
S. LeRoy
M. Lugo
S. Pahwa
B. Andrews
A. van Luik
D. Jerez
P. Krishn

SAIC***
M. Davis
C. Pflum

SNL++
F. Bingham
G. Barr
M. Wilson
R. Barnard
H. Dockery

USGS#
R. Wallace
D. Hoxie

PNL###
P. Eslinger

Clark Co., Nevada
E. van Tiesenhausen

NRC
S. Coplan
M. Lee
N. Eisenberg
J. Park
R. Byrne

CNWRA**
B. Gurgeghian
M. Miklas

State of Nevada
S. Frishman
P. Spiegler

LLNL+
A. MacIntyre

Weston
C. Noronha
D. Dresser
V. Killpack

NWTRB+++
L. Reiter

LANL##
K. Birdsell
G. Valentine

State of New Mexico°
A. Channell
A. Gallegos

* TRW Environmental Safety Systems
** Center for Nuclear Waste Regulatory Analyses
*** Science Application International Corporation
+ Lawrence Livermore National Laboratory
++ Sandia National Laboratory
+++ U.S. Nuclear Waste Technical Review Board
# U.S. Geological Survey
Los Alamos National Laboratory
Pacific Northwest Laboratory
° Energy Evaluation Group

U.S. NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS

PRESENTATION FOR NRC/DOE TECHNICAL EXCHANGE ON SCENARIOS AND CCDF CONSTRUCTION

SUBJECT: NRC PERFORMANCE ASSESSMENT CONCERNS - DOE'S SCP, NRC'S SCA, AND DOE'S RESPONSE TO NRC'S SCA

PRESENTER: N.A. EISENBERG

PRESENTER'S TITLE AND ORGANIZATION: SENIOR OPERATIONS ANALYST
HYDROLOGY & SYSTEMS PERFORMANCE BRANCH
DIVISION OF HIGH-LEVEL WASTE MANAGEMENT
OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS
U.S. NUCLEAR REGULATORY COMMISSION

PRESENTER'S TELEPHONE NUMBER: (301) 504-2324

APRIL 28-29, 1992

ATTACHMENT 3

TABLE 1

STATUS OF SCA OPEN ITEMS

SCA Open Item		Status
OBJECTION	1	Open
	2	Open
COMMENT	1	Open
	2	Open
	3	Open
	4	Open
	5	Open
	6	Open
	7	Open
	8	Open
	9	Open
	10	Open
	11	Open
	12	Open
	13	Closed
	14	Closed
	15	Open
	16	Open
	17	Closed
	18	Open
	19	Open
	20	Open
	21	Open
	22	Open
	23	Closed
	24	Open
	25	Open
	26	Closed
	27	Closed
	28	Closed
	29	Closed
	30	Closed
	31	Open
	32	Open
	33	Open
	34	Open
	35	Open
	36	Open
	37	Closed
	38	Closed
	39	Closed
	40	Closed

TABLE 1 (Continued)

STATUS OF SCA OPEN ITEMS

SCA Open Item		Status
COMMENT	41	Closed
	42	Open
	43	Open
	44	Closed
	45	Open
	46	Closed
	47	Open
	48	Open
	49	Open
	50	Closed
	51	Open
	52	Open
	53	Open
	54	Closed
	55	Open
	56	Open
	57	Open
	58	Closed
	59	Open
	60	Open
	61	Open
	62	Open
	63	Open
	64	Open
	65	Closed
	66	Open
	67	Closed
	68	Open
	69	Open
	70	Closed
	71	Open
	72	Open
	73	Open
	74	Open
	75	Open
	76	Closed
	77	Open
	78	Closed
	79	Open
	80	Open

TABLE 1 (Continued)

STATUS OF SCA OPEN ITEMS

SCA Open Item		Status
COMMENT	81	Open
	82	Open
	83	Closed
	84	Open
	85	Open
	86	Open
	87	Open
	88	Open
	89	Open
	90	Open
	91	Open
	92	Closed
	93	Closed
	94	Closed
	95	Open
	96	Open
	97	Closed
	98	Open
	99	Open
	100	Open
	101	Open
	102	Open
	103	Open
	104	Open
	105	Open
	106	Open
	107	Closed
	108	Open
	109	Open
	110	Open
	111	Closed
	112	Open
	113	Open
	114	Closed
	115	Open
	116	Open
	117	Open
	118	Open
	119	Open
	120	Open

TABLE 1 (Continued)

STATUS OF SCA OPEN ITEMS

SCA Open Item		Status
COMMENT	121	Open
	122	Open
	123	Open
	124	Closed
	125	Closed
	126	Closed
	127	Open
	128	Open
	129	Closed
	130	Open
	131	Closed
	132	Open
	133	Closed
QUESTION	1	Open
	2	Closed
	3	Open
	4	Closed
	5	Open
	6	Closed
	7	Closed
	8	Open
	9	Open
	10	Closed
	11	Closed
	12	Open
	13	Closed
	14	Open
	15	Open
	16	Closed
	17	Open
	18	Closed
	19	Closed
	20	Open
	21	Open
	22	Open
	23	Open
	24	Closed
	25	Open

TABLE 1 (Continued)

STATUS OF SCA OPEN ITEMS

SCA Open Item		Status
QUESTION	26	Closed
	27	Closed
	28	Open
	29	Closed
	30	Open
	31	Open
	32	Open
	33	Open
	34	Open
	35	Open
	36	Open
	37	Open
	38	Open
	39	Open
	40	Open
	41	Open
	42	Open
	43	Closed
	44	Open
	45	Open
	46	Open
	47	Open
	48	Closed
	49	Open
	50	Closed
	51	Open
	52	Closed
	53	Open
	54	Closed
	55	Open
	56	Open
	57	Open
	58	Open
	59	Open
	60	Closed
	61	Open
	62	Open
	63	Closed

Chapter 8	Site Characterization Program
Section 8.0	Introduction
Section 8.1	Rationale
Section 8.3	Planned Tests, Analyses, and Studies
Section 8.3.1	Site Program
Section 8.3.5	Performance Assessment Program

SCA COMMENT 1

Although the SCP commits to a systematic, iterative approach to identifying the information needed to support a license application (the Issue Resolution Strategy), the documentation in the SCP does not demonstrate that such a program is in place. While this comment includes several concerns not raised elsewhere, it also collects and summarizes concerns expressed in other comments, which collectively point to the absence of such a program.

EVALUATION OF DOE RESPONSE

- The NRC staff's interest in a systematic, iterative process results from the view that such an approach would best assure that the site characterization program will be of sufficient scope and appropriate detail to result in a complete license application. Comment 1 stated concerns about whether the systematic, iterative process described in the SCP would accomplish this goal. In its response, DOE agreed to use iterative performance assessment to refine the initial performance allocation described in the SCP. However, the responses to Comments 1 and 6 indicate that DOE has no plans to revise the hypothesis testing tables. The responses state instead that DOE will use data obtained during site characterization to test the hypotheses now articulated in the hypothesis testing tables. This approach does not resolve the staff's concern that the scope of the site characterization program may be too narrow and its concern about whether the studies identified in the SCP would adequately investigate the alternative conceptual models.

- Moreover, the DOE response addresses the recommendation of Comment 1 by referring to additional DOE documents that have either not been reviewed or not been evaluated by the NRC staff in the context of this comment. Therefore, Comment 1 is open. Closure will require NRC staff's review of the referenced documents to assure that its recommendations are being addressed. As a minimum the NRC staff needs to review the following documents:

    1. Test and Evaluation Plan
    2. Technical Support Documentation Management Plan
    3. Report to Congress on Reassessment of the Civilian Radioactive Waste Management Program
    4. Baselined portions of the SCP

Section 8.3.5.13 Total System Performance

SCA COMMENT 95

The underlying methodological logic that is used to develop and screen scenarios and its implementation in the SCP appears to be deficient for the generation of a CCDF representative of total system performance; therefore, this approach is unsuitable for guiding the site characterization program, even if allowances are made for the current lack of knowledge about the site and the expediencies required to develop the site characterization program.

EVALUATION OF DOE RESPONSE

- DOE recognizes that scenario development is an iterative process, stating that DOE "continues to work on scenario development and will do so as long as reasonable questions arise from site investigations or public concern." DOE's response provides some additional discussion of the process that DOE intends to use for scenario development.

- DOE's response suggests a general convergence of views regarding most of the subjects raised by the NRC staff in this comment. However, one significant issue is not addressed in DOE's response -- the NRC staff's recommendation for explicit criteria for development and screening of scenarios. DOE indicates that "project participants" will be requested to add to or subtract from a scenario event tree, apparently based on their subjective judgment of the significance of their additions or deletions. The NRC staff continues to believe that DOE should develop explicit criteria for such additions or deletions.

- The NRC staff considers this comment open. While DOE's views and those of the staff appear to be converging, an interaction is needed to continue progress toward resolution of differences. The NRC staff is particularly concerned about the absence of explicit criteria for scenario development and screening.

Section 8.3.5.13 Total System Performance

SCA COMMENT 98

Weighting alternative conceptual models according to the judgment that they are likely to be correct and using such "probabilities" to weight consequences in the construction of the CCDF is not a conservative estimate of repository performance, nor is it an advisable approach for demonstrating compliance.

EVALUATION OF DOE RESPONSE

- o In its response, DOE agrees that weighting alternative conceptual models according to their likelihood of being correct and incorporating such likelihoods into the CCDF characterizing repository performance does not necessarily produce a conservative estimate of repository performance.

- o DOE suggests that it could construct a family of CCDF's to demonstrate the impact of uncertainty in conceptual models on repository performance. Such an approach, rather than the combination of such CCDF's as stated in the SCP, has the advantage of providing more information in an accessible fashion to the NRC staff and licensing board.

- o If DOE has in fact adopted an approach that does not combine results from alternative conceptual models according to the judgment that they are likely to be correct, the original comment is resolved; however, the DOE response is not a clear commitment to that effect.

- o The DOE response also raises a new issue. DOE states that it would use a Bayesian approach to eliminate alternative conceptual models from consideration. Although Bayesian statistical approaches have been used extensively in recent years to address issues of nuclear safety, the NRC staff does not agree that posterior probabilities should be used to eliminate conceptual models no longer consistent with the updated information. The staff would prefer hypothesis testing conducted in the traditional context of the scientific method; i.e. the site characterization program should attempt to acquire data from critical experiments that will disqualify incorrect alternative concepts. The application of Bayes' theorem to choose among alternative conceptual models has theoretical and practical difficulties; these include (1) a degree of arbitrariness in determining prior probabilities and likelihood functions and (2) the possibility that no posterior probability associated with a set of alternative conceptual models will be large enough to rule out the other alternatives.

- o The NRC staff considers this comment open.

Section 8.3.5.13 Total System Performance

SCA COMMENT 99

For some scenario classes in which a particular release mode is thought to dominate or, at least, dominate for a particular time period, the consequences that are calculated may not be adequately represented unless all of the release modes are quantified, especially the residual part of the inventory continuing to participate in the nominal or undisturbed mode(s) of release. Premature and inappropriate limiting of the consequence analysis in this way may distort the performance allocation process so that insufficient priority is placed on some data or important data acquisition activities may be omitted from site characterization.

EVALUATION OF DOE RESPONSE

- NRC commented that DOE might be distorting the performance allocation process by ignoring undisturbed release modes when considering dominant release modes. NRC recommended that all appropriate modes of release should be included in the consequence analysis unless they can be eliminated as being insignificant. Furthermore, all modes of release should be calculated, and the performance allocation process should include all modes of release.

- DOE replied that it agreed with all NRC recommendations and believes that they were already incorporated into the planned work. They stated that disruptive scenarios are treated as perturbations to the nominal cases. In making the comment the NRC staff considered that the SCP did not reflect this approach. Accordingly, the issue will be resolved when DOE provides the NRC staff with information indicating how various release pathways enter into performance allocation and the calculations of the CCDF.

- The NRC staff considers this comment open.

Section 8.3.5.13 Total System Performance

SCA COMMENT 100

There are two problems with the sequences for faulty waste emplacement (pp. 8.35.13-32 to 33): (1) sequences for faulty waste emplacement establish the initial condition for the repository at time of closure and should not be included in the set of scenarios, and (2) the sequences are so limited, it is not clear that the site characterization program will acquire the data to analyze the likelihood and consequences of such initial defects.

EVALUATION OF DOE RESPONSE

- DOE does not respond directly to the NRC staff's suggestion that faulty waste emplacement be treated as an initial condition rather than as an event to be included in a scenario analysis.

- The NRC staff considers this comment open.

Section 8.3.5.13 Total System Performance

SCA COMMENT 101

Equation 8.3.5.13-21, which is used to estimate "the partial performance measure for the jth scenario class involving releases along the water pathway" [sic; see Comments 95 and 99 for an explanation of why it is not appropriate to define scenario classes in terms of release mode] appears to have been derived on the basis of inconsistent assumptions and may be in error.

EVALUATION OF DOE RESPONSE

- DOE replies that the assumptions used in deriving Eq. 8.3.5.13-21 in the SCP are valid when the fractional release rate r_i is valid. It points out that the expression for S_i on page 8.3.5.13-70 was incorrect, and gives the correct expression from a later publication than the one originally cited. The main point DOE makes in its reply, however, is that the model embodied in the SCP is preliminary, included for illustration only to make the theoretical discussion clearer.

- It is the NRC's staff understanding from its review of the SCP, that the model was also included in the discussion for the purpose of deriving parameter goals for performance allocation. Consequently, the NRC staff considers that this comment will be closed when the appropriate changes are made to the performance allocation.

- The NRC staff considers this comment open.

Section 8.3.5.13 Total System Performance

SCA COMMENT 102

The model for Ross sequences number 10 (p. 8.3.5.13-29), 14 and 15 (p. 8.3.5.13-30) seems to be at variance with the hydrologic model of flow at Yucca Mountain; because (as in this case) the basis for developing scenarios to guide the site characterization program appears to be inconsistent, site characterization may fail to provide the information needed for licensing.

EVALUATION OF DOE RESPONSE

- In DOE's response to Comment 95 (referred to in the response to this comment), the DOE states that "[t]he statement that 'scenarios should be limited to descriptions of the external constraints, in time, on the system' [from NRC staff Comment 95] is not consistent with DOE's use of the term 'scenario.'"

- Under DOE's definition of a scenario, the conceptual models for vertical and lateral flow conditions may be in effect at the same time, i.e., within the same scenario. DOE feels that to develop scenarios from only those sequences incorporating the current conceptual model of infiltration and flow at Yucca Mountain would place undue severe restrictions on the event and processes lists and therefore on DOE's overall scenario development methodology.

- The NRC staff considers that alternative conceptual models, e.g., only vertical flow downward versus vertical plus lateral flow at the site, should be separated from the events and processes used to develop the scenarios. Further, a systematic exhaustive approach to scenario development should be followed separately for individual alternative site conceptual models.

- The NRC staff considers this comment open. The staff considers that an interaction is needed in order to come to a resolution regarding a mutually acceptable definition for a "scenario" and methodology for scenario development.

Section 8.3.5.1 Total System Performance

SCA COMMENT 103

Ross sequence numbers 59-62 and 64-69 appear to characterize either anticipated conditions or alternative conceptual models, rather than scenarios.

EVALUATION OF DOE RESPONSE

- The NRC staff commented on the DOE characterization as scenarios of some anticipated conditions or alternative conceptual models. The NRC staff recommended that DOE include anticipated conditions and alternative conceptual models in its plans to characterize the site, and not call them scenarios. DOE responded that, in using event trees to construct scenarios, DOE defines a scenario as a path through the tree from initiating event to radionuclide release to the water table. Consequently, the scenarios would include these types of processes and events, even if they differed from scenario to scenario.

- It is not clear that the DOE approach is consistent with probability theory or the NRC staff interpretation of 40 CFR 191. The NRC staff interprets 40 CFR 191 as incorporating parameter uncertainty and future states uncertainty into the CCDF. Attempts to include other uncertainties may confound decisions regarding acceptability of the repository.

- The NRC comment remains open. It should be addressed in a future NRC/DOE interaction.

Section 8.3.5.13 Total System Performance

SCA COMMENT 104

The Ross sequences appear to be based entirely on spent fuel as the waste form; since these sequences presumably form a basis for the site characterization program, it is not clear that important scenarios that may be peculiar to vitrified HLW have not been omitted.

EVALUATION OF DOE RESPONSE

o The NRC staff commented that DOE based its scenarios on spent-fuel waste form only, and neglected any ramifications of vitrified HLW. DOE replied that it will consider vitrified HLW within the context of its general scenario selection procedure that considers all important processes.

o The NRC staff considers this comment open because DOE did not respond directly to it in terms of definite scenarios and other appropriate augmentation of the site characterization program. Closure can occur if such augmentation is provided in DOE's iterative performance assessment and semiannual SCP Progress Reports.

Section 8.3.5.13 Total System Performance

SCA COMMENT 105

Although DOE may incorporate material by reference in the licensing application and although scenarios already eliminated may not need to be treated in calculating the CCDF in the license application, sufficient data, and analyses, or justification should be accumulated during site characterization to substantiate the decision to eliminate these scenarios.

EVALUATION OF DOE RESPONSE

- In its response, DOE agrees that the SAR will need extensive discussions about scenario selection. DOE refers to the discussion on technical support documentation (TSD) in the response to Comment 1 which, in the third paragraph on page 18 describes the TSD as consisting of technical reports and licensing documents that will synthesize data gathered in SCP studies and compile and interpret information acquired about the site. Also, in the discussion in Section 8.3.5.13 of the SCP, DOE refers to the iterative nature of the scenario screening process. The response relies primarily on the iterative nature of the process. As site data are acquired, updated models would indicate priority data needs and detailed reasons for eliminating scenarios.

- The point of NRC's comment lies in its basis as well as its recommendation. There is no reason to think that an iterative process would necessarily bring back scenarios that were eliminated at an early stage. Care must be taken in eliminating scenarios in a systematic manner that allows the data to be accumulated during site characterization to justify the decision to eliminate the scenarios.

- The NRC staff considers this comment open. Discussion at an interaction on scenario identification and screening would, in part, focus on this issue and would be a first step in bringing the issue to closure.

Section 8.3.5.13 Total System Performance

SCA COMMENT 106

There appears to be a missing coupling term in equation 8.3.5.13-12B; this equation is the primary basis for calculating liquid-phase radionuclide transport to the accessible environment.

EVALUATION OF DOE RESPONSE

- DOE acknowledged that the SCP was in error, and that the missing term should be included as stated by the NRC staff. However, DOE also states that the discussion following the equation in error did not depend on the omission, so no changes to site characterization are necessary. The NRC staff disagrees. It is the NRC staff's view that the missing term should have led to entries in the Hypothesis Testing Table that are not there and should have affected the performance allocation program.

- The NRC staff considers this comment open.

Section 8.3.5.13 Total System Performance

SCA COMMENT 107

Although the introduction of a waiting time in equation 8.3.5.13-24 may, in general, be acceptable from a theoretical viewpoint, care must be taken to assure a correct implementation of the concept, both in generating an empirical CCDF and in approximating performance for purposes of guiding site characterization.

EVALUATION OF DOE RESPONSE

- In the response, DOE first clarifies that the "waiting time" is intended to be a random variable, quoting the statement on page 8.3.5.13-67 that, with certain exceptions, "all the variables appearing on the right-hand side of the Equation 8.3.5.13-21 may be regarded as random variables." Even so, it is stated that Equation 8.3.5.13-21 is not intended to be a final model for releases to the accessible environment.

- DOE briefly addresses the problem of determining the probability distribution for the occurrence of geologic events. It is stated that a Poisson approximation would be made only if it were justified by available information. Further, it is stated that there probably would be no waiting time for alternative conceptual models and undetected features.

- The NRC staff considers that its concerns regarding justification of values for waiting times, if used, have been understood and addressed.

- The NRC staff considers this comment closed.

Section 8.3.5.13 Total System Performance

SCA COMMENT 108

The use of the EPPM (expected partial performance measure) to screen scenarios and to establish goals for the performance allocation used to guide site characterization may be justified on a theoretical basis, but does not appear to be appropriately implemented in the SCP.

EVALUATION OF DOE RESPONSE

- DOE states that "[the] attainment of a performance allocation goal does not guarantee compliance. In the absence of site characterization data, the allocations are based on reasonable expectations that, if met, the allocations are likely to lead to a successful demonstration of compliance."

- In the SCP discussion of performance allocation, the overall licensing strategy is defined as "the basis for current DOE plans to show compliance with regulatory requirements." Performance allocation goals, in turn, are assigned by DOE using values consistent with the licensing strategy for the issue involved. In light of this, the NRC staff considers that the performance allocation goals should be chosen so that, given the right conditions, meeting these goals should guarantee compliance with the regulations.

- DOE states that, although some EPPMs are greater than 0.01 in Table 8.3.5.13-9, this is not an indication that the site will fail. DOE expects all EPPMs will be smaller than their table values. Additionally, DOE does not see the need to check the EPPM contribution of all omitted scenario classes because the condition such that the EPPM sum for all scenarios is less than 0.01 is only a sufficient condition.

- The NRC staff considers that the use of the EPPM and Equation 8.3.5.13-9 have been misapplied in the performance allocation table for Issue 1.1 (SCP Table 8.3.5.13-8) as stated in the comment. It is not clear to the NRC staff how the formulation of Equation 8.3.5.13-9 was applied to Table 8.3.5.13-8.

- The NRC staff considers this comment open.

Section 8.3.5.13 Total System Performance

SCA COMMENT 110

The response to CDSCP comment 90 indicates that human intrusion is intended to be left out of the calculation of the CCDF, but the SCP text is unclear as to how human intrusion will be handled.

EVALUATION OF DOE RESPONSE

- DOE's response indicates neither acceptance of the NRC staff's interpretation of the requirements of EPA's HLW standards nor any concrete proposal by DOE for evaluating the significance of potential human activities. Instead, DOE indicates that "meetings and other interactions" between DOE and NRC are needed.

- The NRC staff is willing to meet with DOE on this subject. If DOE disagrees with the standards (as appears to be the case), then it should raise the issue with EPA as the standards are being revised.

- The NRC staff considers this comment open.

Section 8.3.5.13 Total System Performance

SCA COMMENT 112

There is a gap in the discussion of the treatment of state variables as constants or as random variables.

EVALUATION OF DOE RESPONSE

- o Although the DOE response addresses the logical gap in the discussion, it does not satisfy the NRC recommendations.

  (1) Since the "coefficient of variation" (CV) is the standard term for the ratio of a random variable's standard deviation to its mean, this term should be used.

  (2) Apparently, there are two conditions for treating a state variable as a constant: (i) if the CV is very small or (ii) if the "results of a calculation" are not sensitive to changes in the state variable. The first condition is explicitly stated but the second condition must be inferred from the last sentence in the third paragraph. Since condition (i) implies condition (ii), it should be explicitly stated that condition (ii) is the defining criterion. Furthermore, "results of a calculation should be replaced by "performance measure" and some attempt should be made to define what is meant by "not sensitive."

  (3) Once the conditions for treating a state variable as a constant are clearly stated, it should be explicitly stated that a state variable which fails to satisfy these conditions must be treated as a random variable. This will serve the purpose of treating all ambiguous state variables as random variables, thus preventing a situation where a state variable with a significant contribution to the uncertainty of a performance measure is treated as a constant.

- o The NRC staff considers this comment open.

Section 8.3.5.13 Total System Performance

SCA COMMENT 113

The definition of the unit step function is not consistent with the definition of the CCDF.

EVALUATION OF DOE RESPONSE

- Although DOE agrees that it would be "more consistent" to define the unit step function as stated in the NRC recommendation, DOE does not state whether or not it will change its definition of the unit step function. If DOE does not change its definition, then the definition will remain inconsistent with the definition of the CCDF on page 8.3.5.13-5 and might lead to ambiguity in determining the regulatory compliance of the site.

- In the second sentence of its response DOE seems to imply that the definition of the unit step function will have "no impact on determining the regulatory compliance of the site." This is not correct. For example, suppose that $M < 1.0$ with probability 0.8 and $M = 1.0$ with probability = 0.2. Since

  $$Pr(M > 1.0) = Pr(M > 10.0) = 0,$$

  the site satisfies the containment standard given by equation 8.3.5.13-2. However, if the definition of $u(X)$ given on page 8.3.5.13-9 is used, then $G(1.0) = 0.2$ and the containment standard is not satisfied.

- The NRC staff considers this comment open. A step toward closure may be inclusion of this topic for discussion at a future NRC-DOE interaction on the generation of the CCDF.

Section 8.3.5.13 Total System Performance

SCA COMMENT 115

There is an incorrect statement that the CCDF can be expanded in terms of scenario classes as in Figure 8.3.5.13-2 only if the entities comprising the scenario classes are statistically independent.

EVALUATION OF DOE RESPONSE

- Currently, DOE is not planning to revise the SCP, but proposed a paragraph for addition to the SCP should it be updated in the future. The suggested paragraph (denoted by PAR 1) for inclusion on page 8.3.5.13-13 is almost correct when considered by itself (see below), but it should be inserted at a different place in the text, and the text needs additional modification. First, PAR 1 should be inserted after the paragraph beginning on the bottom of page 8.3.5.13-13 and continuing on page 8.3.5.13-14 (denoted by PAR 2), not before. Since PAR 2 deals with two-state alternative models based on independent objects and since PAR 1 deals with a generalization of this framework, PAR 1 should follow PAR 2. Second, the phrase "provided that they are statistically independent entities" in PAR 2 should be changed to indicate that statistical independence is not a necessary condition but rather a special case.

- The next to last sentence of PAR 1 implies that the order of occurrence of E^1 and E^2 is a further complication; in fact, the example is based on E^1 occurring, if it does occur, before E^2. A suggested replacement is as follows: "Even more complicated situations may arise, for example, where sometimes E^1 precedes E^2 and sometimes E^2 precedes E^1." Also the term "dependencies" should be used instead of "correlation," as it is the more general term. (It is possible for two events to be dependent but uncorrelated.)

- Following PAR 1, it should be noted that a model based on dependent objects presents additional complications in estimating the conditional probabilities.

- The NRC staff considers this comment open, because as explained above, the proposed resolution is incomplete.

Preliminary Draft

APRIL 28-29, 1992
DOE/NRC TECHNICAL EXCHANGE
CORRELATON OF SCA COMMENTS WITH AGENDA TOPICS

SCA Number	SCA Comment	Agenda Topic
1.	Use of iterative performance assessment to refine performance allocation; and,	All
	Plans to revise hypothesis testing tables	Opening remarks
95.	Criteria for development and screening of scenarios	Scenario Generation
98.	Approach to combining the results from alternative conceptual models in the construction of the CCDF; and,	CCDF Construction
	Approach to eliminating alternative conceptual models	
99.	Approach to combining the results from various release pathways in the calculation of the CCDF	CCDF Construction
100.	Treatment of faulty waste emplacement as an initial condition rather than an event to be included in a scenario analysis	Scenario Generation
101.	Approach for deriving parameter goals for performance allocation based on the expected partial performance method (EPPM)	Definitions

ATTACHMENT 4

SCACMNT.125/4-23-92

Preliminary Draft

APRIL 28-29, 1992
DOE/NRC TECHNICAL EXCHANGE
CORRELATON OF SCA COMMENTS WITH AGENDA TOPICS
(CONTINUED)

SCA Number	SCA Comment	Agenda Topic
102.	Treatment of alternative conceptual models should be separate from events and processes in the development of scenarios	Definitions and Scenario Generation
	Scenario development for individual alternative site conceptual models;	Scenario Generation
	Definition of "scenario"; and,	Definitions
	Methodology for scenario development	Scenario Generation
103.	Treatment of anticipated conditions and alternative conceptual models; and,	Definitions and Scenario Generation
	Interpretation of 40 CFR 191 as incorporating only parameter uncertainty and future states uncertainty into the CCDF	Definitions
104.	Treatment of vitrified high-level waste within scenario selection procedure	Opening remarks & Scenario Generation
105.	Systematic manner for eliminating scenarios	Scenario Generation

Preliminary Draft

APRIL 28-29, 1992
DOE/NRC TECHNICAL EXCHANGE
CORRELATON OF SCA COMMENTS WITH AGENDA TOPICS
(CONTINUED)

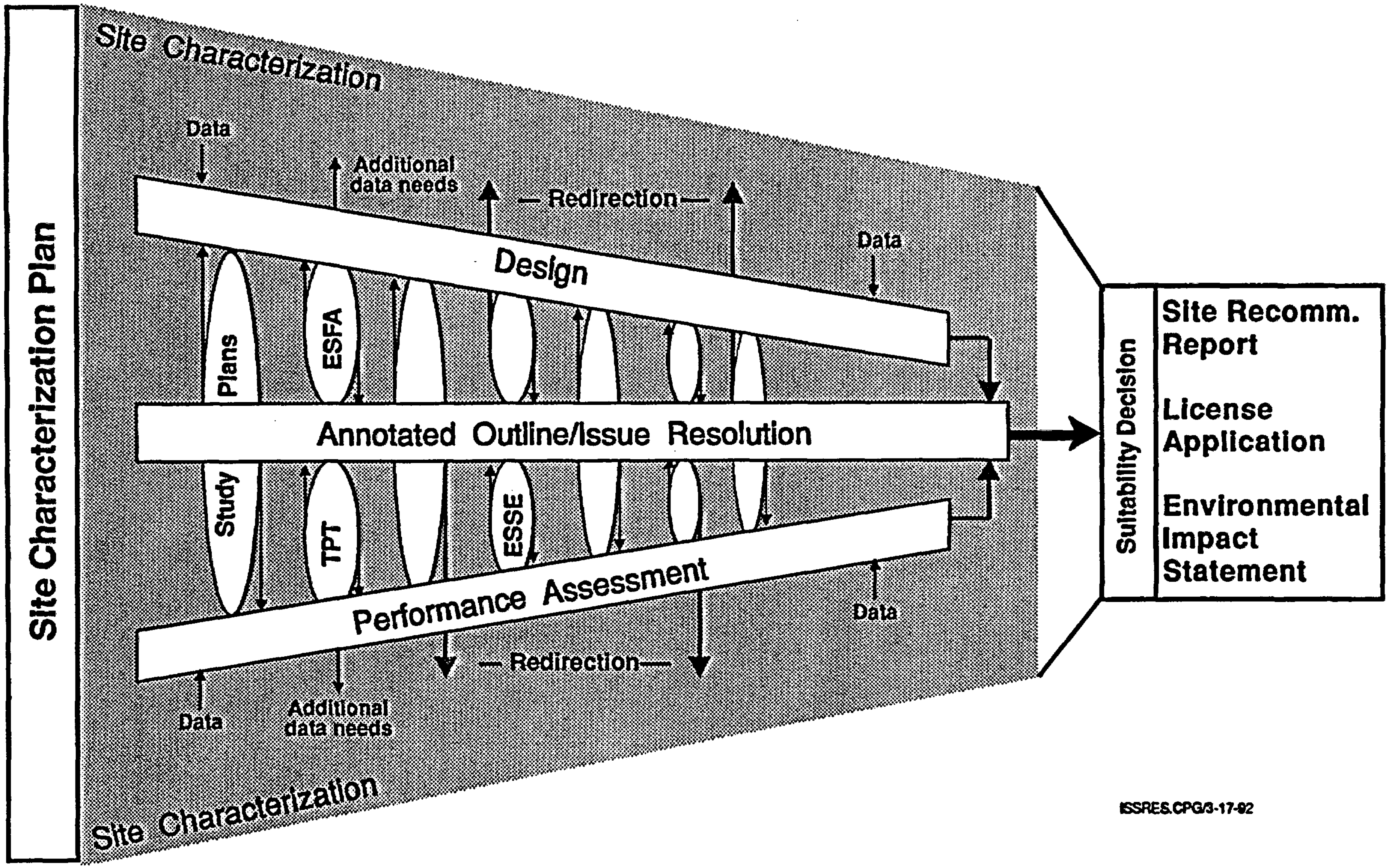
SCA Number	SCA Comment	Agenda Topic
106.	Completeness and updates to hypothesis testing tables and use of these tables in site characterization	Opening Remarks
108.	Implementation of the EPPM to screen scenarios and guide site characterization	CCDF Construction
110.	Treatment of human intrusion	CCDF Construction & Example Application
112.	Treatment of state variables as either constant or random	Uncertainties
113.	Definition of the unit step function used in the definition of the CCDF	Opening Remarks
115.	Expansion of the CCDF in terms of scenario classes	CCDF Construction

Note: SCA comments 96, 97, and 109 are not considered because they deal with specific site characterization issues. SCA comments 94, 107, 111, and 114 were not considered because they are considered closed.

SCACMNT.125/4-23-92

Preliminary Draft

Integration of Program Activities



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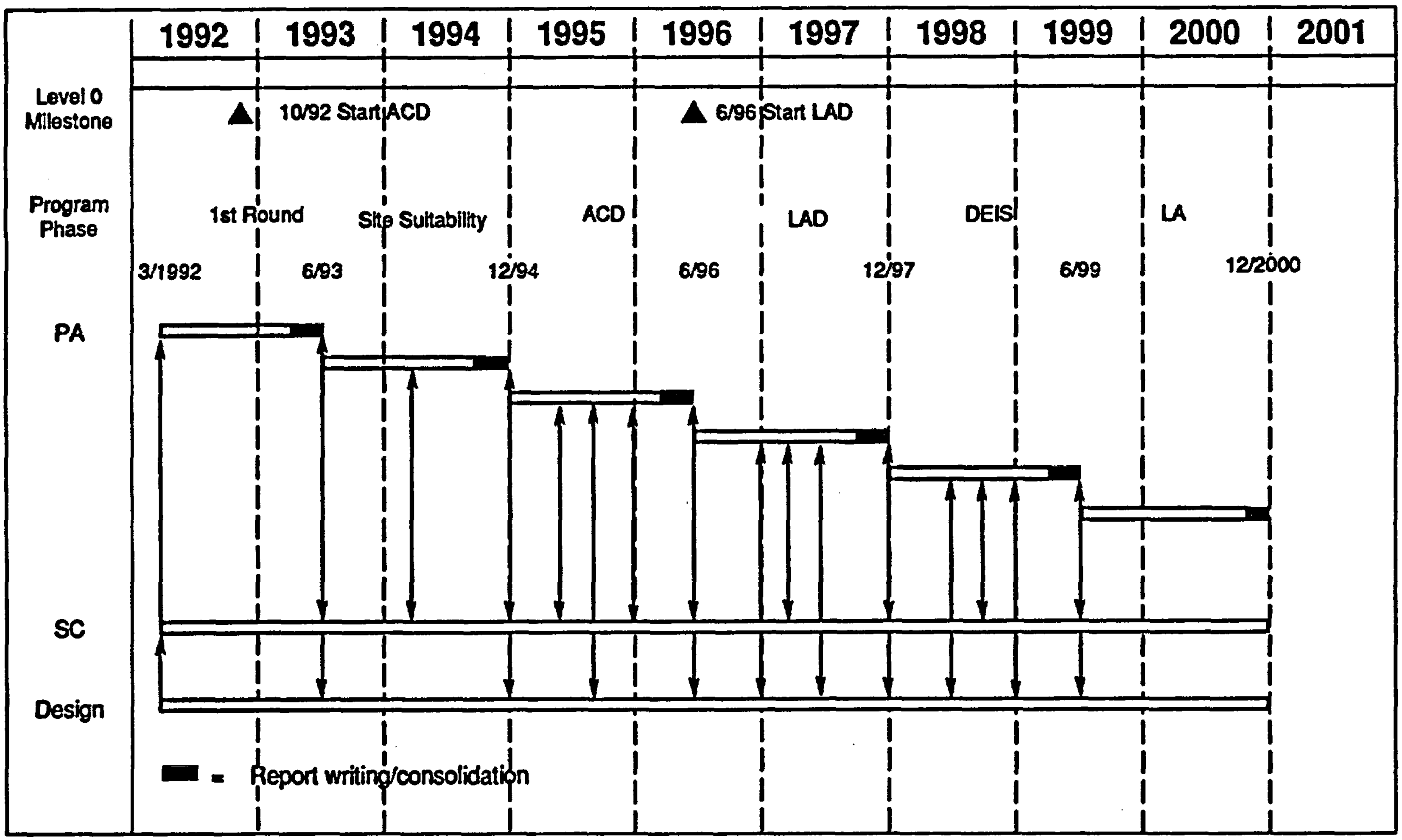
Preliminary Draft

Conceptual Performance Assessment Schedule



Definitions of "Scenario"

A hypothetical sequence of events
(dictionary)

A sequence through a tree ("event tree")
(early WIPP, YMP identification of phenomena)

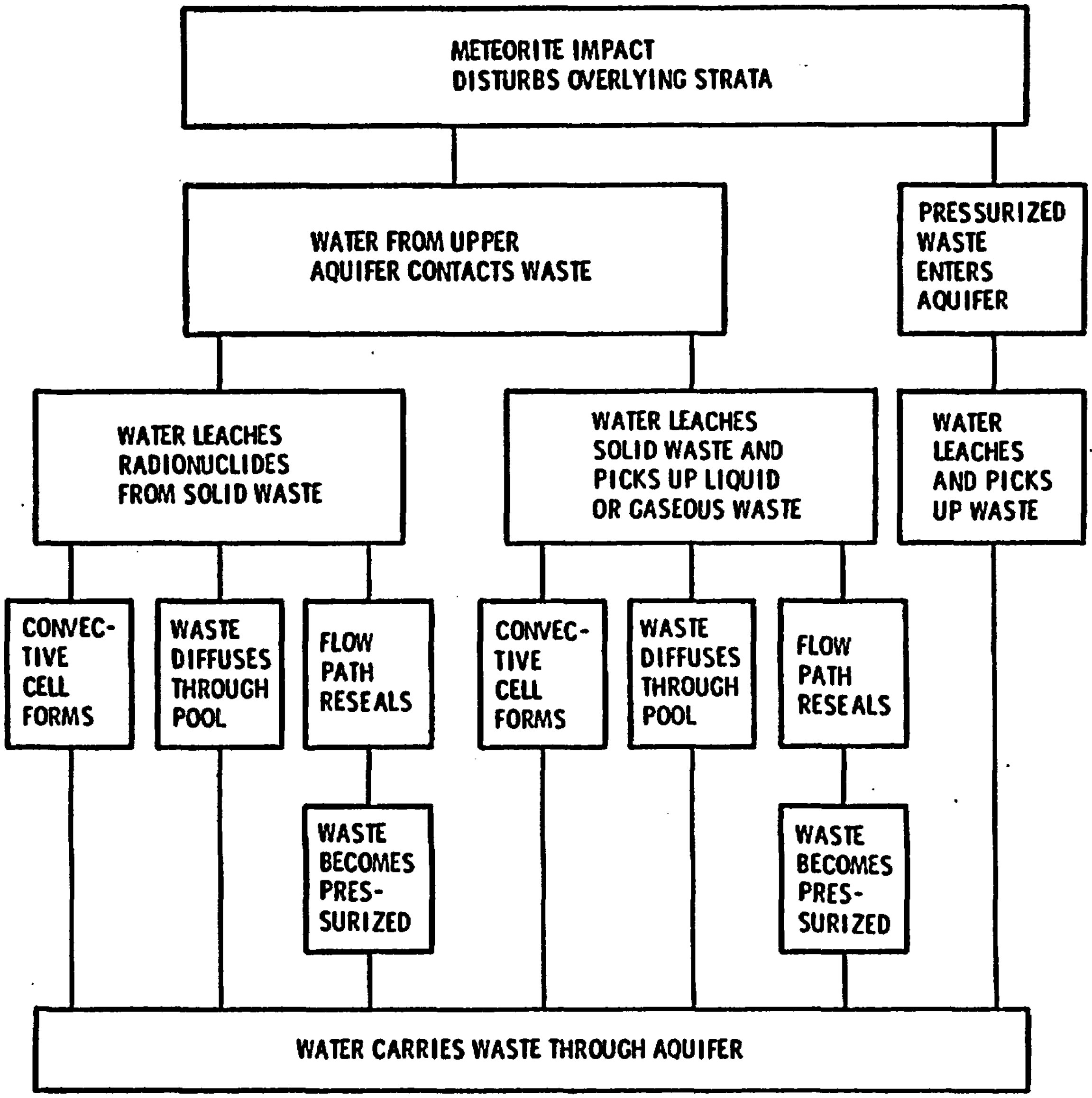
A sequence through a logic diagram
(late WIPP)

A well-defined sequence, formally represented by a vector of parameters
(SCP)

A sequence, restricted to certain phenomena
(NRC in the SCA)

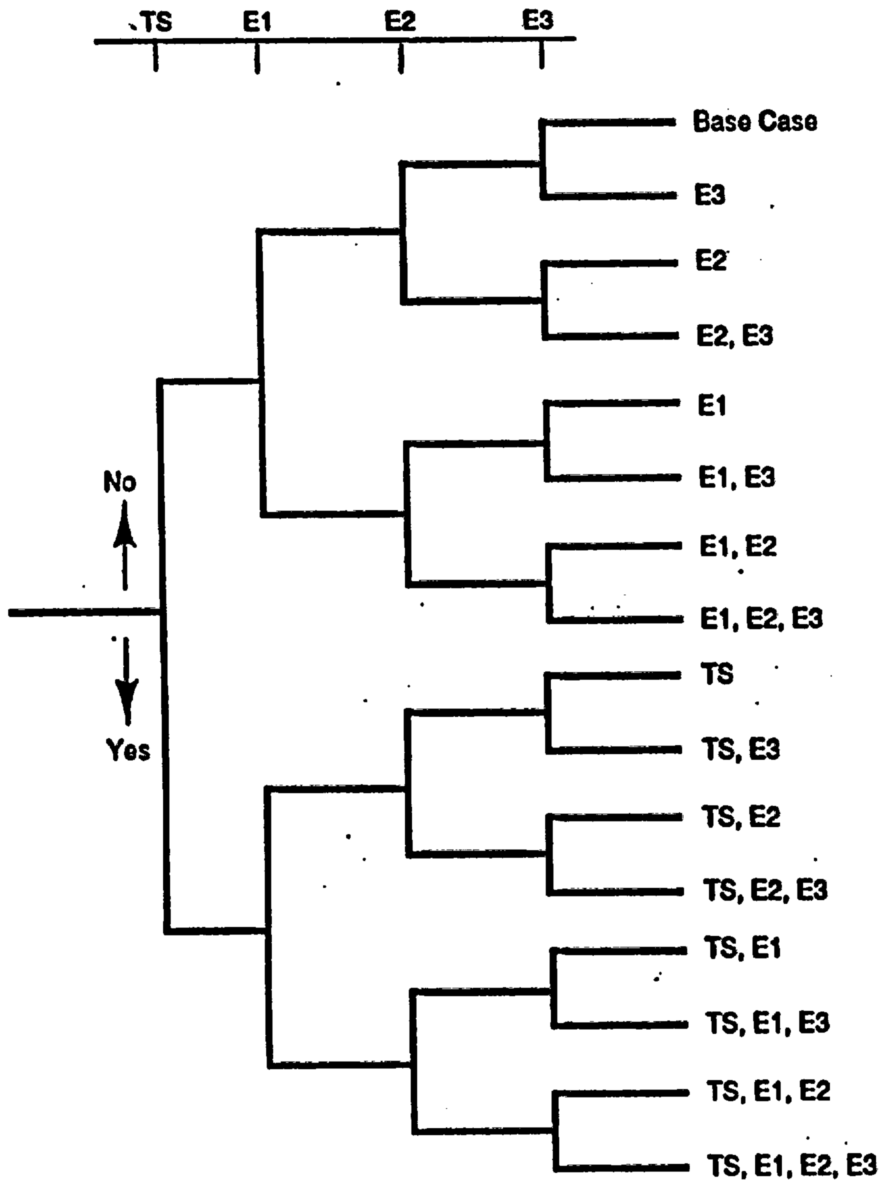
PRELIMINARY DRAFT

Early WIPP Use of "Scenario"



PRELIMINARY DRAFT

Current WIPP Use of "Scenario"



TS - Potash Mining Outside the WIPP Boundary
E1 - Drilling Through Room or Drift and Into Brine Reservoir
E2 - Drilling Into a Room or Drift
E3 - Emplacement of Withdrawal Well Downgradient From Repository

The SCP Use of "Scenario"

Scenario: well-defined sequence

- Events and processes
- Prescribed intensities, time or duration, and order
- Formally, $V = (v_1, v_2, v_3, \ldots v_N)$

Scenario class: collection of all scenarios involving definite types of events or processes

- Values of v_i range freely over the physically possible numerical values

NRC Definition of "Scenario": Limitations in SCA Comments

Scenarios

+ Do not represent response of the repository to external events

+ Are limited to descriptions of external constraints

+ Are future states of nature (?)

+ Do not treat engineered systems stochastically, because design and operational controls must be effective

Definitions of "Alternative Conceptual Model"

(Typical of geologists)

Alternative stratigraphic interpretations

Models on different scales

(Typical of mathematical modelers)

A different mathematical embodiment

(Typical of assemblers of events and processes)

A different set of credible processes

(Typical of ordinary folk)

A different simple mental picture, on which a mathematical model might be based

Which of These Are "Alternative Conceptual Models"?

1. The flow of water is controlled by
   (a) Large-scale features like faults.
   (b) Properties of the rock matrix.
   (c) Strong matrix-fracture coupling.

2. Container degradation occurs primarily through
   (a) Stress-corrosion cracking.
   (b) Uniform corrosion.

3. Flow deep below repository depth occurs through
   (a) Weakly connected horizontal "aquifers."
   (b) Flow downward into a graben.

Questions about "Alternative Conceptual Models"

1. What is the distinction between

   "alternative scenario (class)"
   and
   "alternative conceptual model"
   ?

2. When does the distinction matter?

A Possible Answer to Question 1

A sequence of phenomena is to be called an "alternative conceptual model" (instead of a "scenario class") when

modeling it stochastically is inappropriate.

DRAFT

Types and Treatment of Uncertainty

NRC-DOE TECHNICAL EXCHANGE

DRAFT

R. W. Andrews

April 28, 1992

ATTACHMENT 6

DRAFT

Sources of Uncertainties

- Uncertainties exist in predicting the performance of the Waste Disposal System over 10,000 years

- These uncertainties are a result of uncertainties in:
  - Scenarios
  - Conceptual models
  - Mathematical and computational models
  - Parameters

DRAFT

DRAFT

Sources of Scenario Uncertainty

- Comprehensiveness of events and processes considered

- Uncertainty in scenario screening

DRAFT

DRAFT

Minimizing / Evaluating Scenario Uncertainty

- Systematic method for developing and screening scenarios is intended to provide reasonable assurance that all significant scenarios are included

- Screen on the basis of
  - Physical reasonableness
  - Probability
  - Consequence

DRAFT

- Estimates of scenario uncertainty will be based on direct and indirect evidence, analyses, and formalized expert judgment

Sources of Conceptual Model Uncertainty

DRAFT

- **Alternative conceptual model hypotheses**
  - Coupled processes
  - Spatial / temporal variability
  - Spatial / temporal averaging
  - Extrapolation / interpolation

DRAFT

Minimizing / Evaluating Conceptual Model Uncertainty

- Systematic method of compiling and screening alternative conceptual models

- Test alternative conceptual models

- Evaluate significance of alternative conceptual models in construction of total CCDF

DRAFT

Sources of Mathematical and Computational Model Uncertainty

- **Simplifying assumptions**
  - Linearization of equations
  - Process decoupling
  - Limited dimensions
  - Steady state versus transient

- **Algebraic or programming mistakes**

- **Implementation uncertainty**
  - Discretization
  - Numerical convergence

DRAFT

DRAFT

Minimizing / Evaluating Mathematical and Computational Model Uncertainty

- Verification
- Benchmarking
- Validation
- Technical peer review

DRAFT

DRAFT

Sources of Parameter Uncertainty

- Applicability of laboratory versus in-situ observations
- Applicability of indirect observations
  - Analog data
  - Literature data
- Measurement errors
  - Sampling bias from insufficient observations
  - Instrument error
- Representativeness of measurement to repository conditions
- Data reduction
  - Spatial / temporal variability
  - Test interpretation (conceptual model uncertainty)
  - Spatial / temporal scale of measurement

DRAFT

DRAFT

Minimizing / Evaluating Parameter Uncertainty

- Instrument error reduced by procedural control
- Effect of parameter uncertainty addressed by sensitivity analysis
- Focus parameter uncertainty analysis and site characterization data collection on most sensitive parameters

DRAFT

Summary

• Scenario uncertainty	- Combine all credible scenarios to construct total CCDF
• Conceptual model uncertainty	- Use robust or conservative conceptual models to construct total CCDF - Focus model validation on conceptual models with large uncertainty or significant effect on the total CCDF
• Mathematical / computational model uncertainty	- Reduce by verification / benchmarking - Do not explicitly include in total CCDF
• Parameter uncertainty	- Incorporate in total CCDF - Use conditional CCDF to focus site characterization and design

U.S. NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS

PRESENTATION FOR NRC/DOE TECHNICAL EXCHANGE ON SCENARIOS AND CCDF CONSTRUCTION

SUBJECT: UNCERTAINTY IN REGULATORY DECISIONMAKING

PRESENTER: S.M. COPLAN

PRESENTER'S TITLE AND ORGANIZATION: CHIEF, REPOSITORY PERFORMANCE ASSESSMENT SECTION
HYDROLOGY & SYSTEMS PERFORMANCE BRANCH
DIVISION OF HIGH-LEVEL WASTE MANAGEMENT
OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS
U.S. NUCLEAR REGULATORY COMMISSION

PRESENTER'S TELEPHONE NUMBER: (301) 504-2410

APRIL 28-29, 1992

ATTACHMENT 7

OVERVIEW

- Repository safety assessments will involve large uncertainties.
- Licensing decisions will have to be made in the context of those uncertainties.
- Public confidence will be affected by how those decisions account for uncertainty.
- The current paper presents the staff's general strategy for dealing with uncertainties.

REPOSITORY SAFETY ASSESSMENTS ARE INHERENTLY UNCERTAIN

- Long time period of concern.
- Many scientific disciplines involved - especially earth sciences.
- Need to consider natural and human-initiated disruptions.
- Regulations recognize technical uncertainties, but do not cause them.

UNCERTAINTY AND PUBLIC CONFIDENCE

- The public seeks high confidence that its health and safety will not be endangered.
- Large uncertainties leave room for public skepticism about repository performance.
- If public confidence is to be gained, uncertainties will need to be addressed in an open and adequate way.

NRC STAFF VIEWS ON DEALING WITH UNCERTAINTIES

- Identify uncertainties and quantify them where practical.
- Reduce uncertainties where practical.
- Compensate for uncertainties -- especially those that cannot be quantified.
- Evaluate the significance of residual uncertainties in an open license review.

IDENTIFICATION OF UNCERTAINTIES

- Systematic Regulatory Analyses are being conducted by the staff and CNWRA (Center for Nuclear Waste Regulatory Analyses).
- Repository performance assessments by the staff and CNWRA.
- Identification of uncertainties by other parties, especially DOE.

CLASSIFICATION OF UNCERTAINTIES

- Regulatory - What is required to demonstrate the acceptability of a repository?
- Technical - How is compliance to be shown?
- Institutional - Who does what? (Not at issue in this paper.)

TECHNICAL UNCERTAINTIES

- Technical uncertainties involve the performance of a repository within its future environment.
- Data uncertainty -- the state of the system at repository closure.
- Future states uncertainty -- description of the future repository environment.
- Model uncertainty -- predicted performance of the system within its environment.

REDUCING REGULATORY UNCERTAINTIES

- NRC staff has proposed alternative wording for EPA's probabilistic standards.
- NRC "conforming amendments" to adopt EPA's standards will reduce some uncertainties.
- Staff guidance, including a format and content guide and a license application review plan, has been or will be developed.

REDUCING TECHNICAL UNCERTAINTIES

- Use site-characterization program and avoid unnecessary complexity to reduce technical uncertainties. Site-characterization should provide data for
  - parameter estimates
  - model validation
  - identification of potential disturbances.

COMPENSATION FOR UNCERTAINTIES

- Use of multi-barrier, defense-in-depth design.
- Conservative interpretation of data.

RESIDUAL UNCERTAINTIES

- Attempts to resolve uncertainties early will not always be successful.
- "Residual" regulatory and technical uncertainties will remain to be evaluated during a licensing review.
- The significance of residual uncertainties must be evaluated in a judgmental manner.

TREATMENT OF RESIDUAL UNCERTAINTIES

- "Technical expert judgment" supplements "hard data" for quantifying uncertainties and estimating the effects on performance.
- "Decision-maker judgment" evaluates the regulatory significance of uncertainties.
- Residual uncertainties will be addressed through NRC's established license review process.

TECHNICAL EXPERT JUDGMENT

- Technical expert judgment should be limited to the expert's area of expertise.
- Judgment should not be a substitute for reasonably available and obtainable data or analysis.
- Elicitation methods may help to document the basis for an expert's views.
- Judgments of multiple experts should be combined only with caution and justification.

DECISION-MAKER JUDGMENT

- NRC staff and licensing board must weigh all technical uncertainties.
- When technical experts disagree, the basis for each view must be examined.
- Residual uncertainties must be examined in a "reasonable assurance" context.
- In limited cases, residual uncertainties may be addressed through rulemaking.

SUMMARY

- Repository performance projections are inherently uncertain.

- Public confidence in performance assessments is not likely to be obtained without a significant effort to:
  1. Identify uncertainties
  2. Reduce uncertainties where practical
  3. Compensate for unforseen uncertainties
  4. Openly evaluate the significance of residual uncertainties.

Generation of Scenarios

G. E. Barr

Sandia National Laboratories

Albuquerque, NM

ATTACHMENT 8

Approach to Generating Scenarios

- SCP Method
  - systematic
  - consistent
- Alternative Methods
  - barrier identification
  - fault trees
  - event trees
  - process diagrams
  - expert judgement

PRELIMINARY DRAFT

Scenario Development and Screening Criteria

- Physical Credibility
- Calculated Consequence
- Probability of Occurrence

PRELIMINARY DRAFT

Purpose of a Logical,Systematic Structure

- Communication
- Exhaustion
- Local Completeness

PRELIMINARY DRAFT

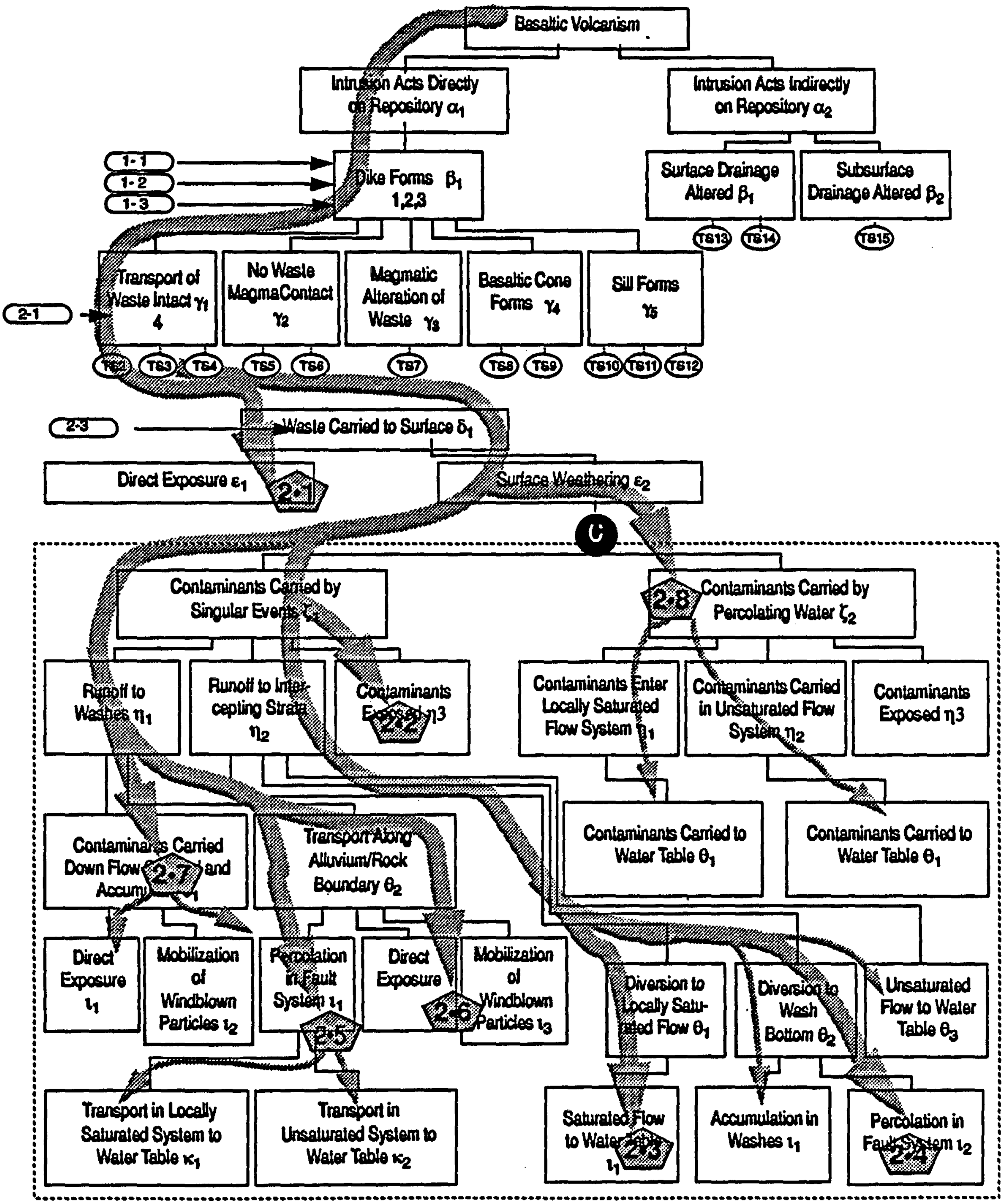
Definition of a Scenario

- Humpty Dumpty
- NRC
- YMP

PRELIMINARY DRAFT

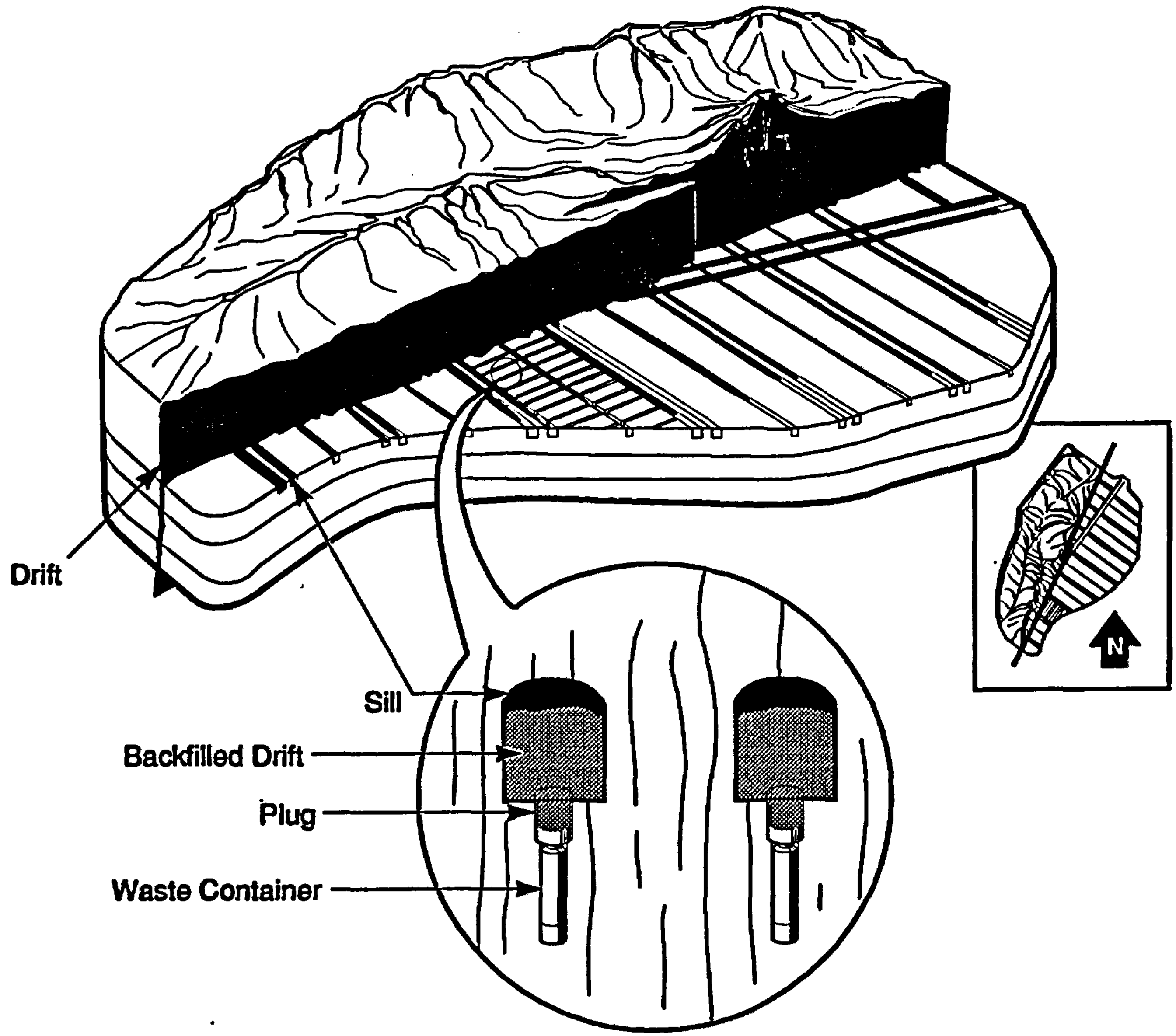
Alternative Conceptual Models or Competing Processes?

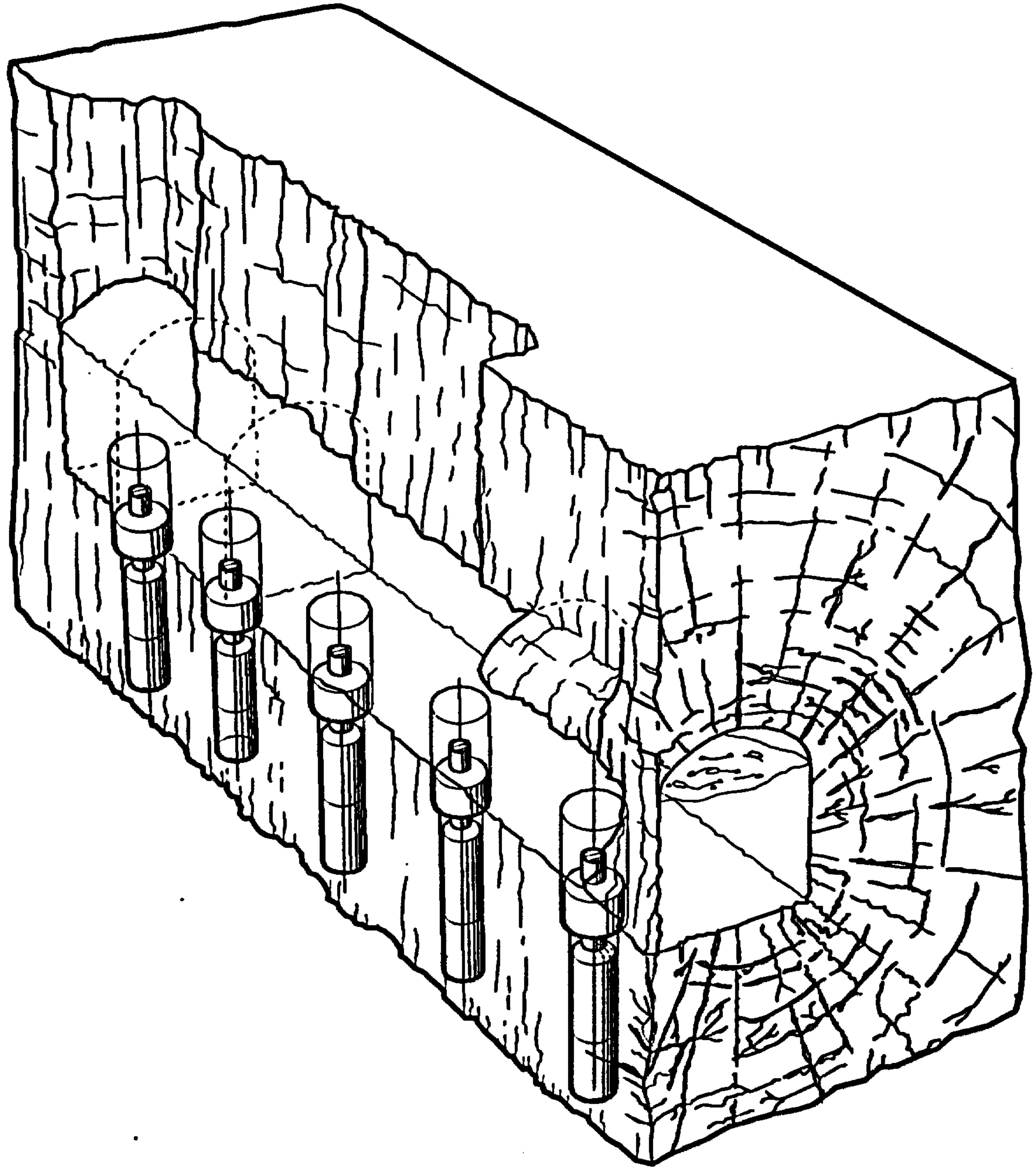
- Irresolvable??
- Examples



Tree Segment 2b. Scenario paths and scenario group paths of tree segment 2a.

PRELIMINARY DRAFT

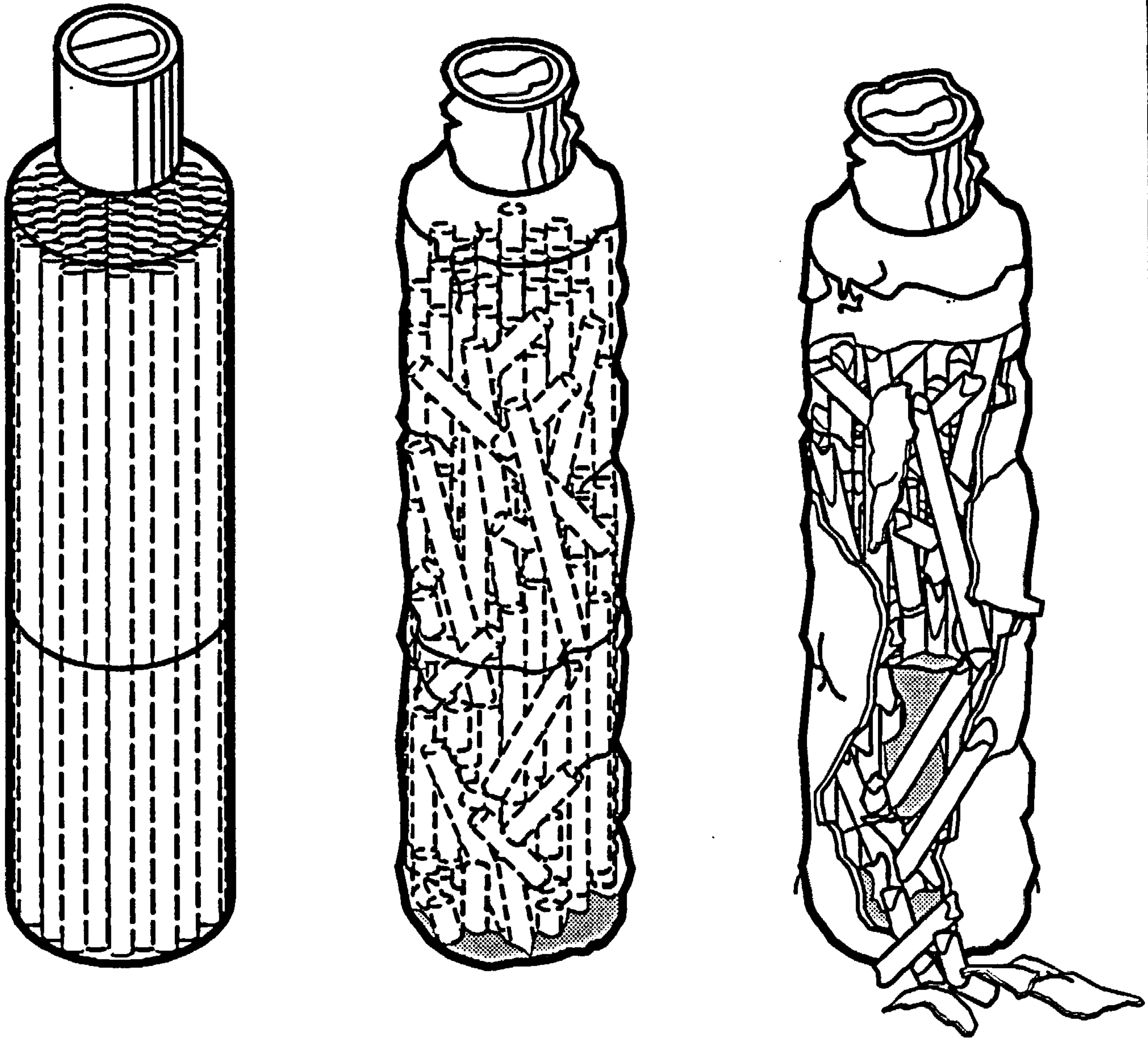

Drift
Sill
Backfilled Drift
Plug
Waste Container
N



PRELIMINARY DRAFT

CONDITION

POSSIBLE CANISTER [redacted]

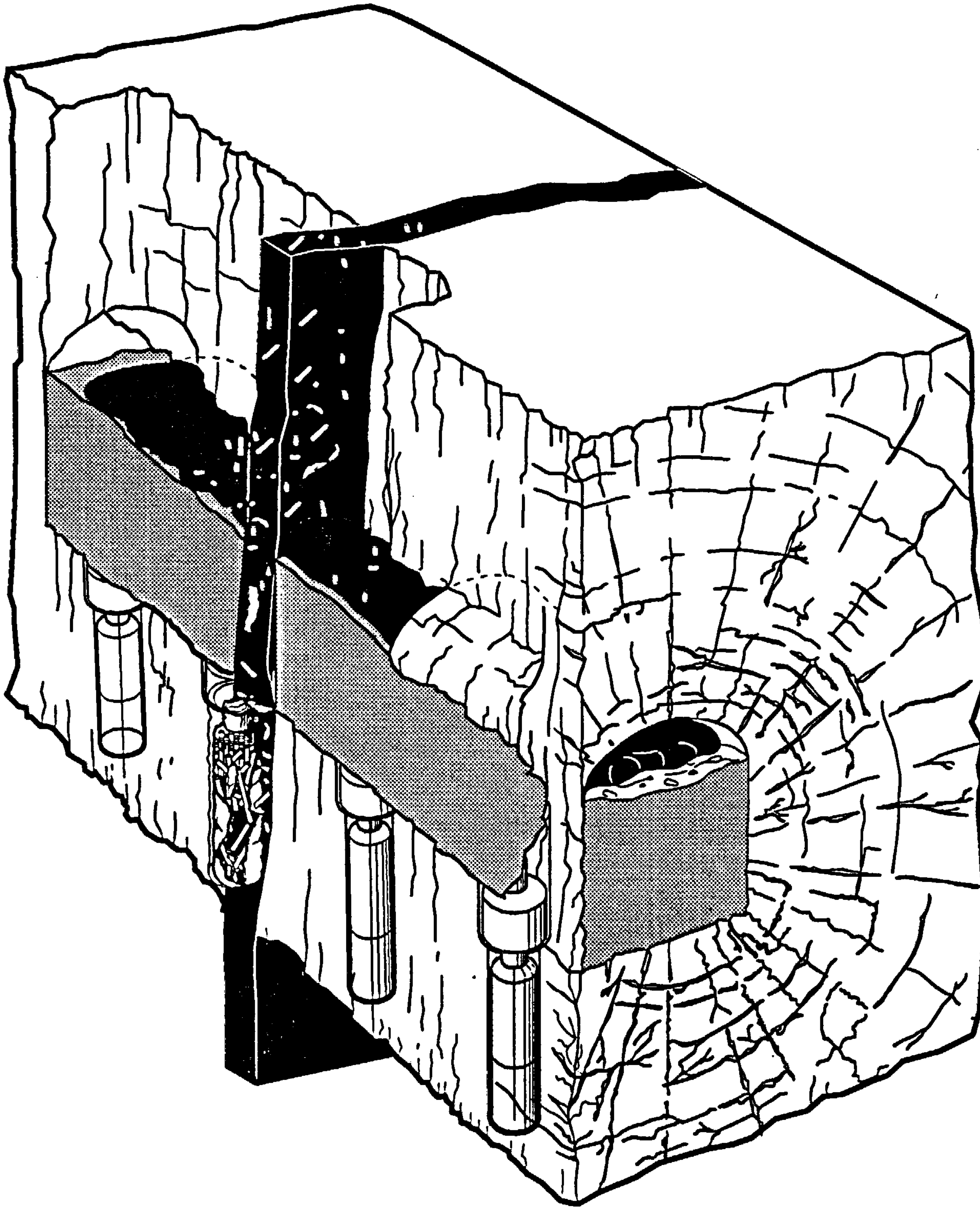


Pristine

Micro Seismic Damage

Corrosion and Seismic Damage

PRELIMINARY DRAFT



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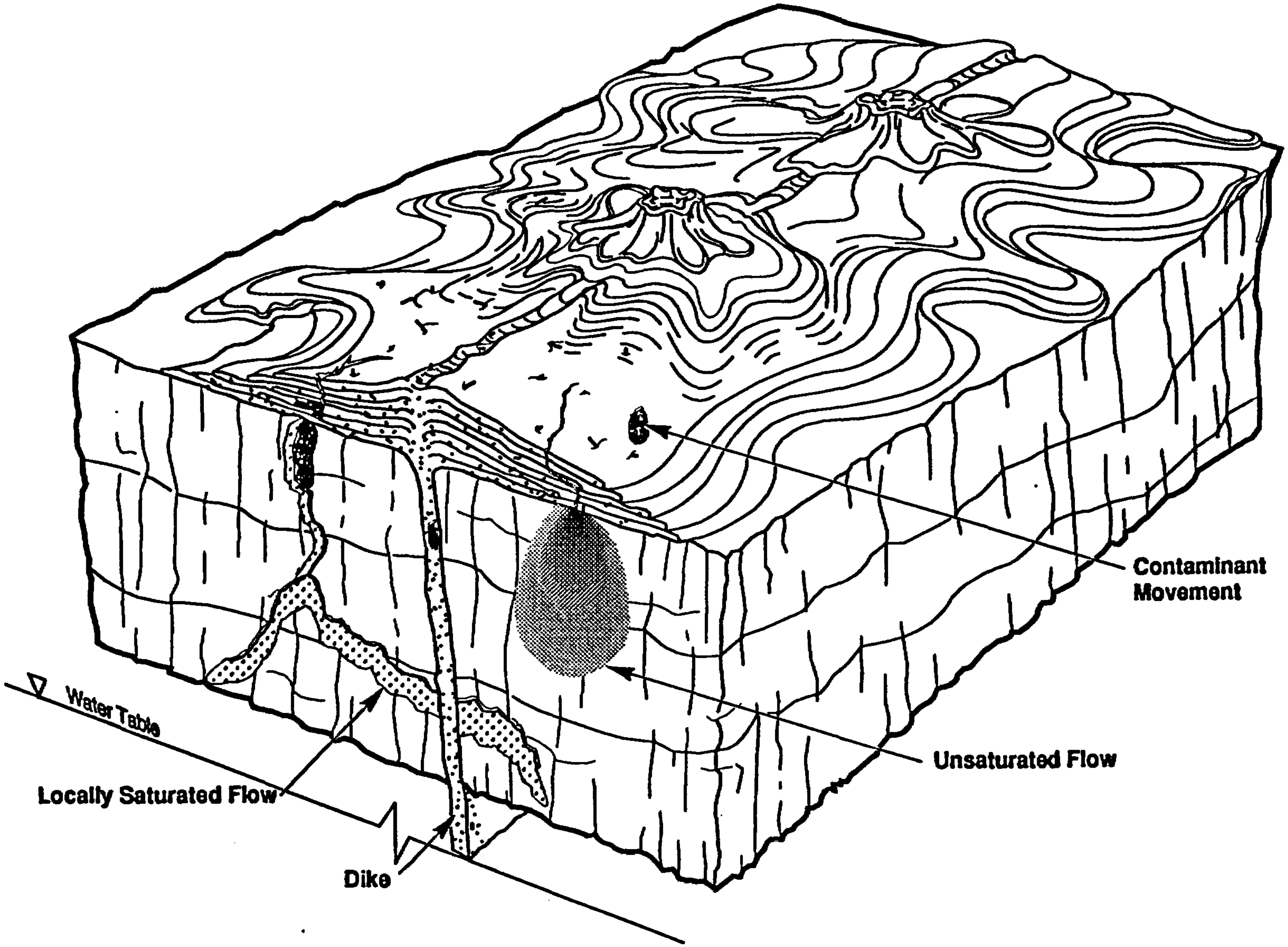

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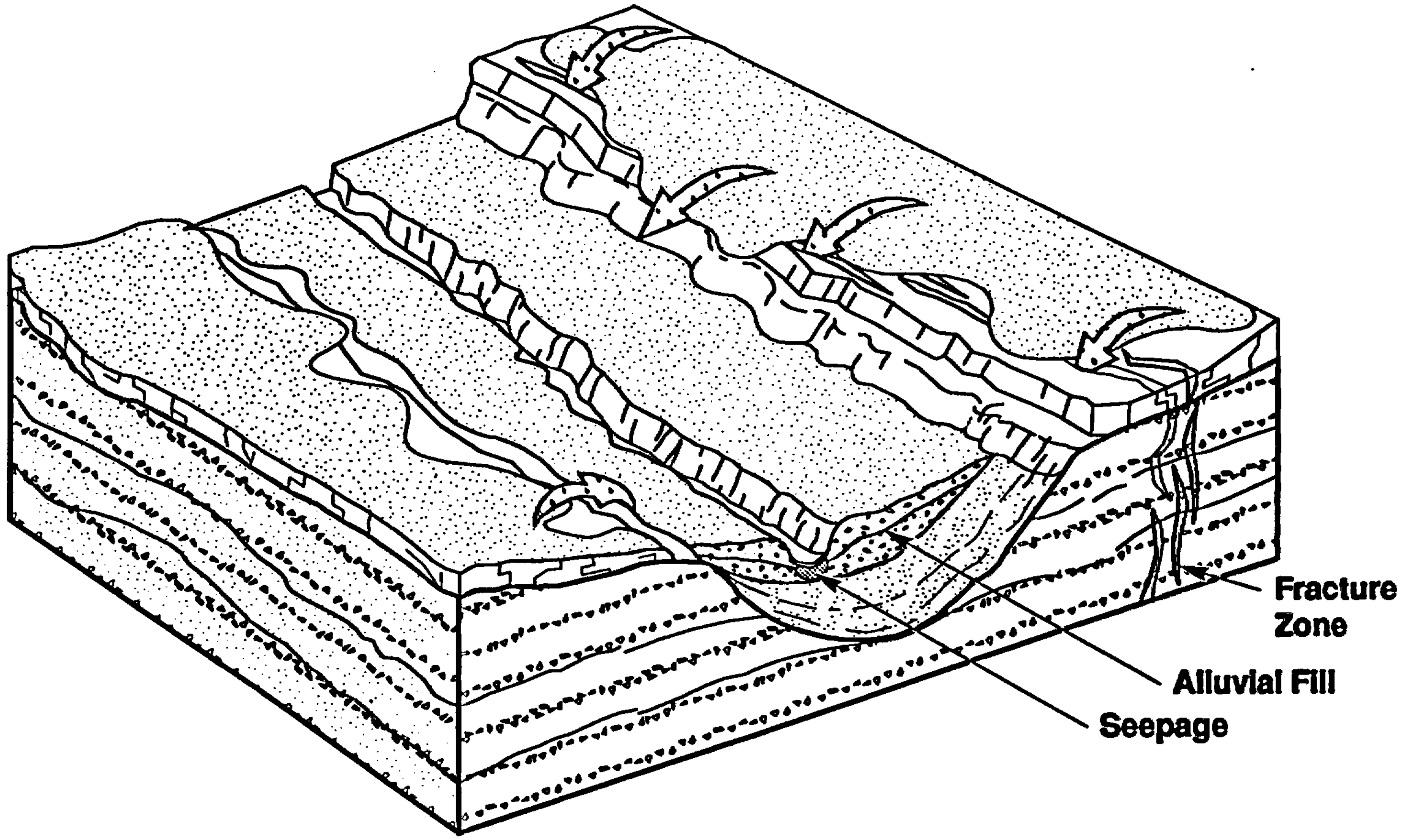
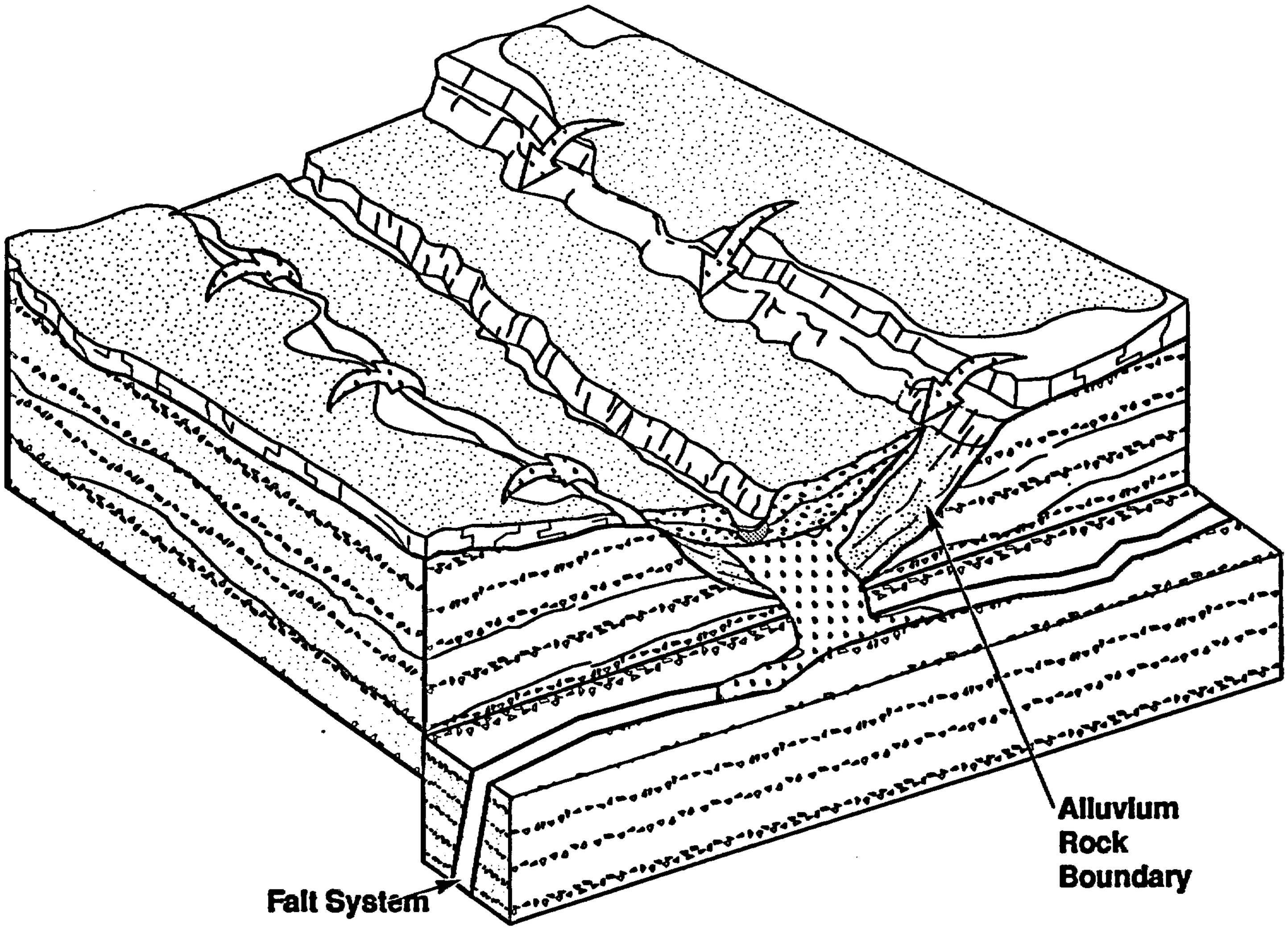
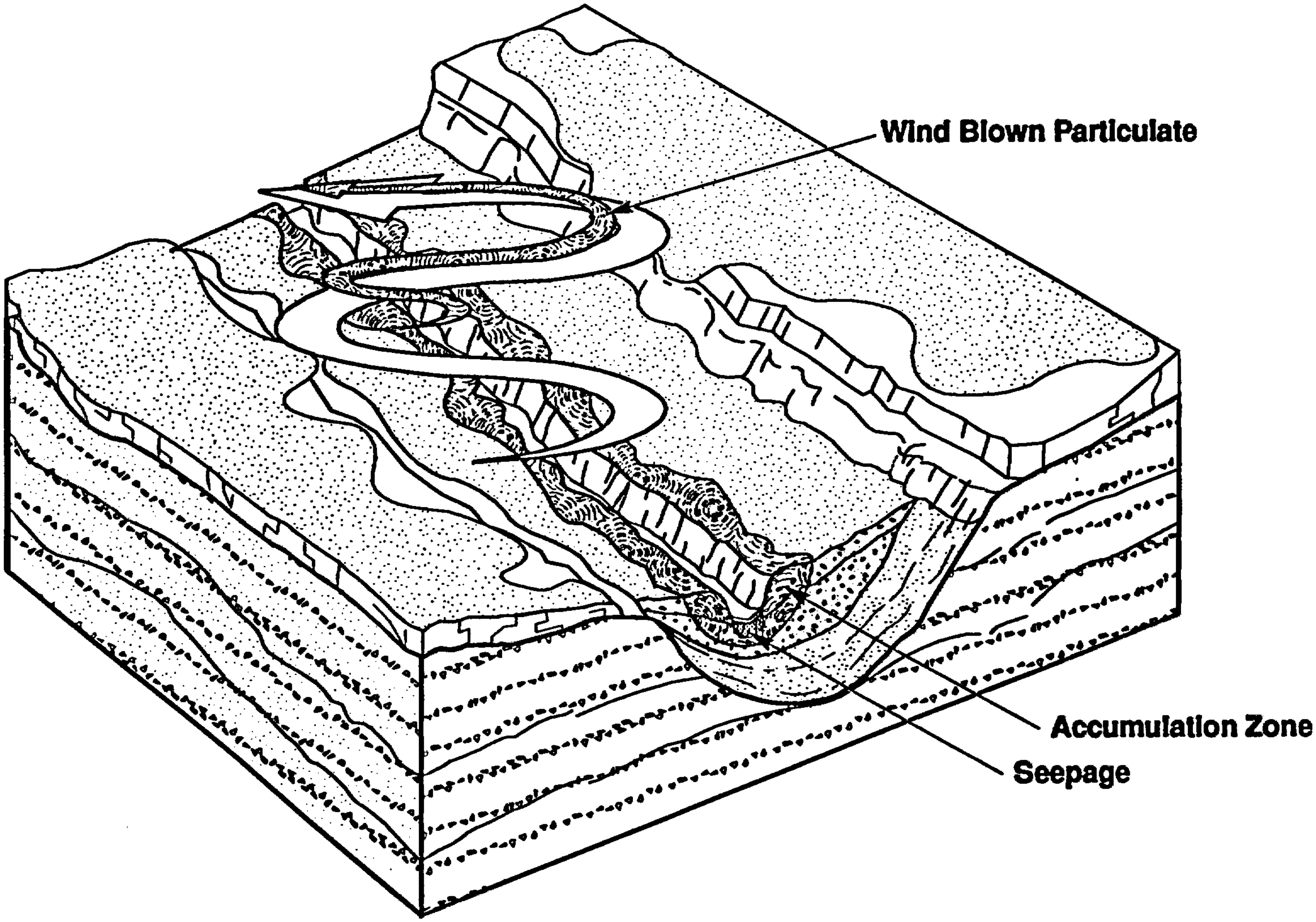
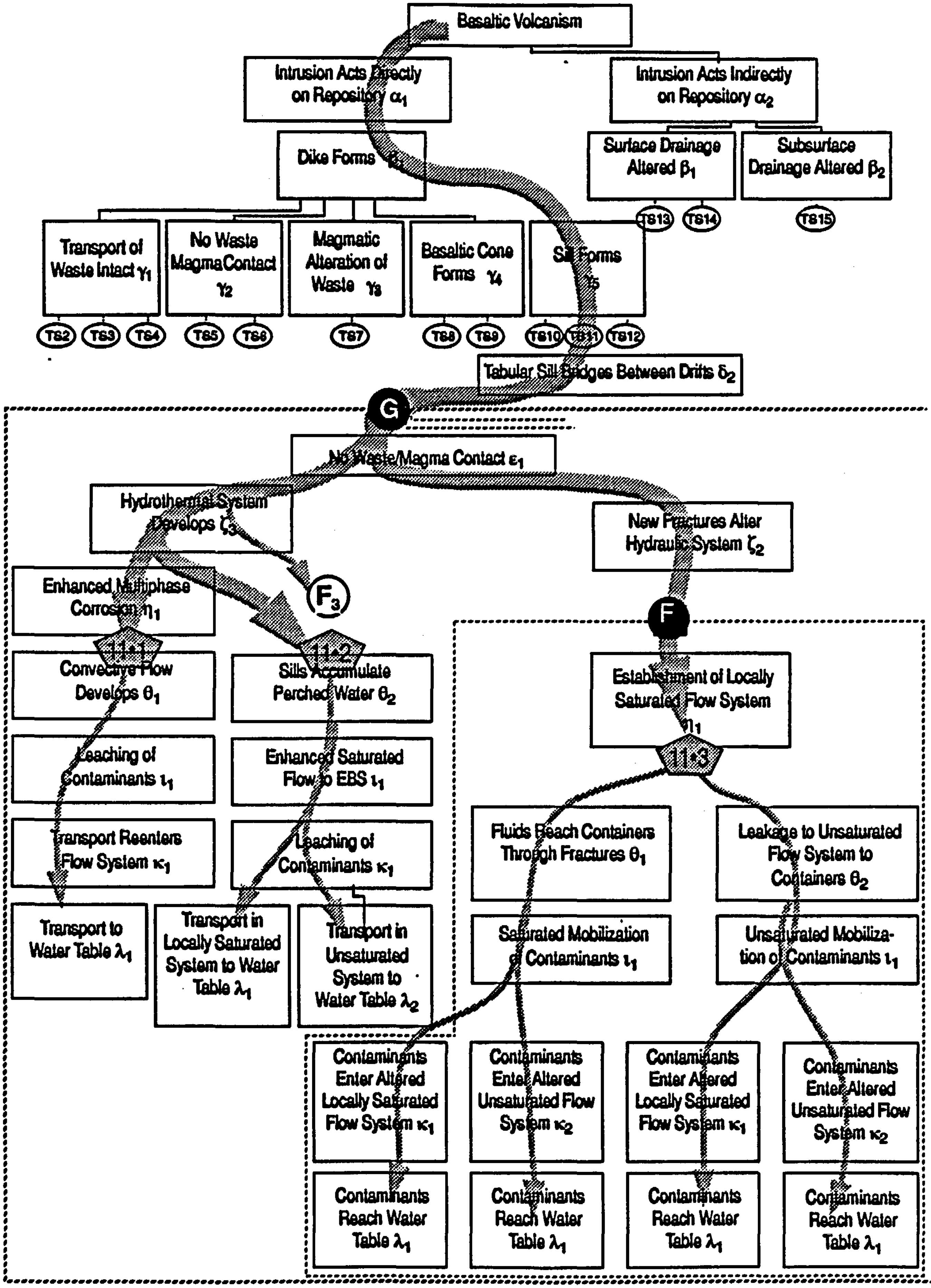

Fracture
Zone
Alluvial Fill
Seepage

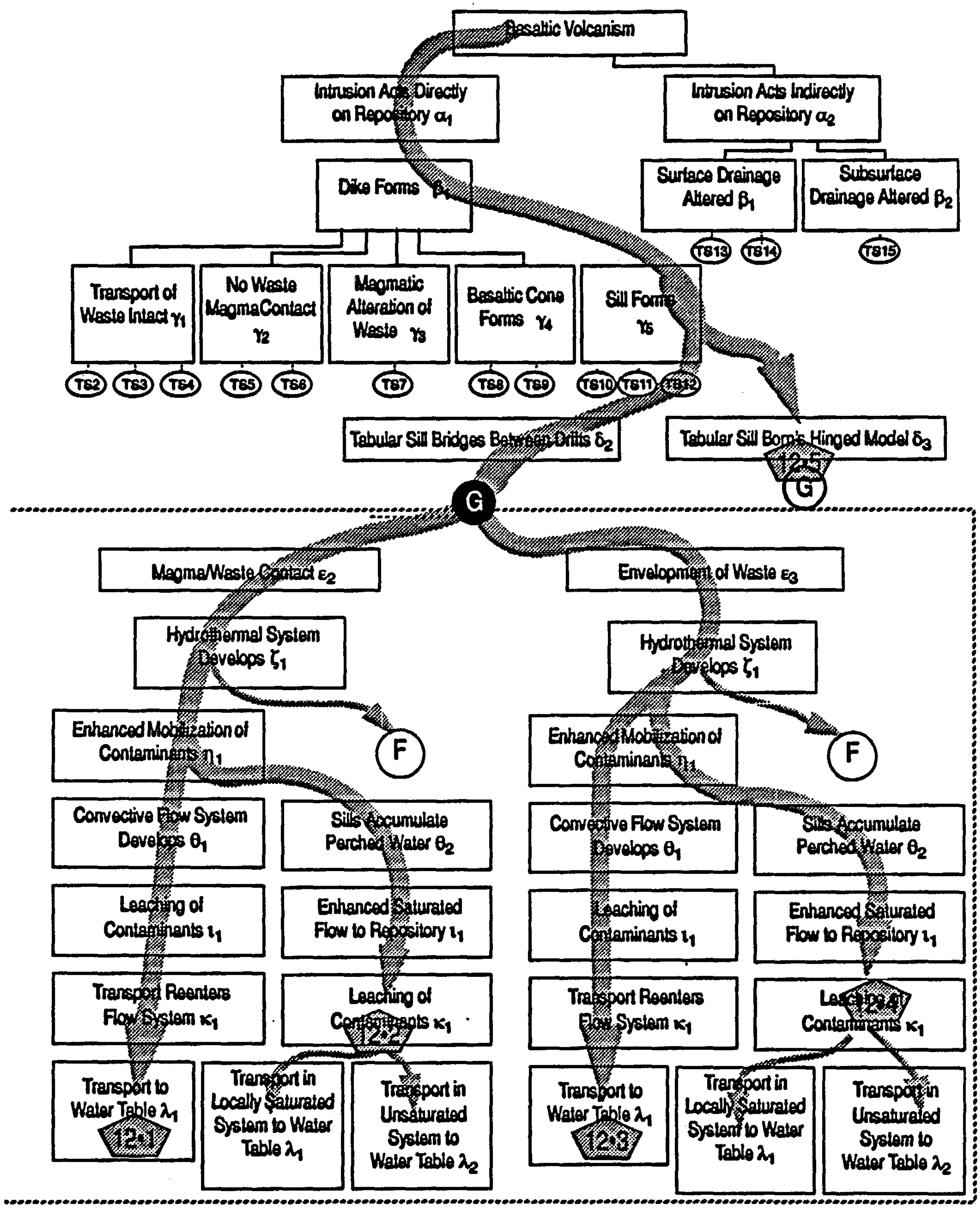

Alluvium
Rock
Boundary
Falt System



PRELIMINARY DRAFT

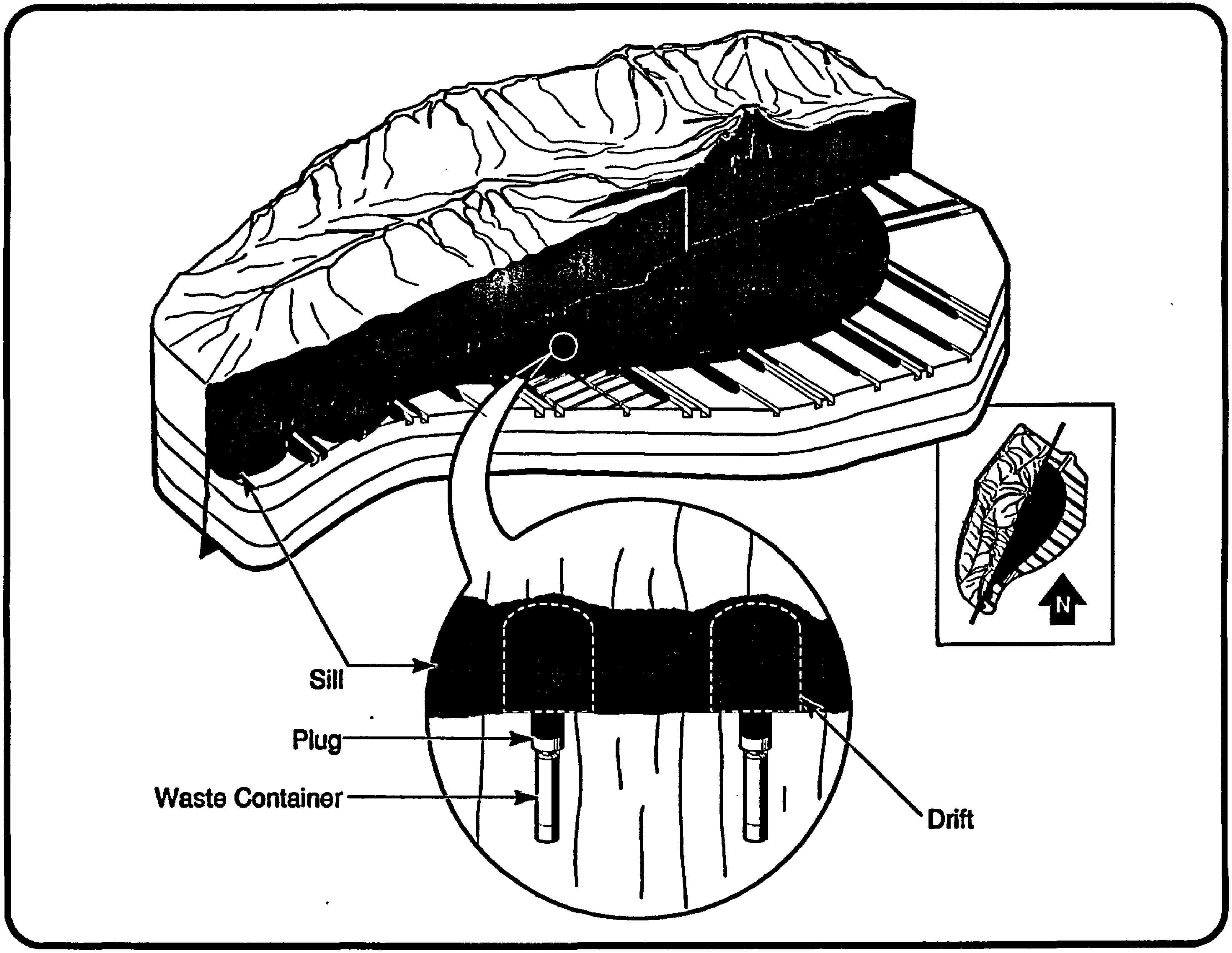


Tree Segment 11b Scenario paths and scenario group paths of tree segment 11a.

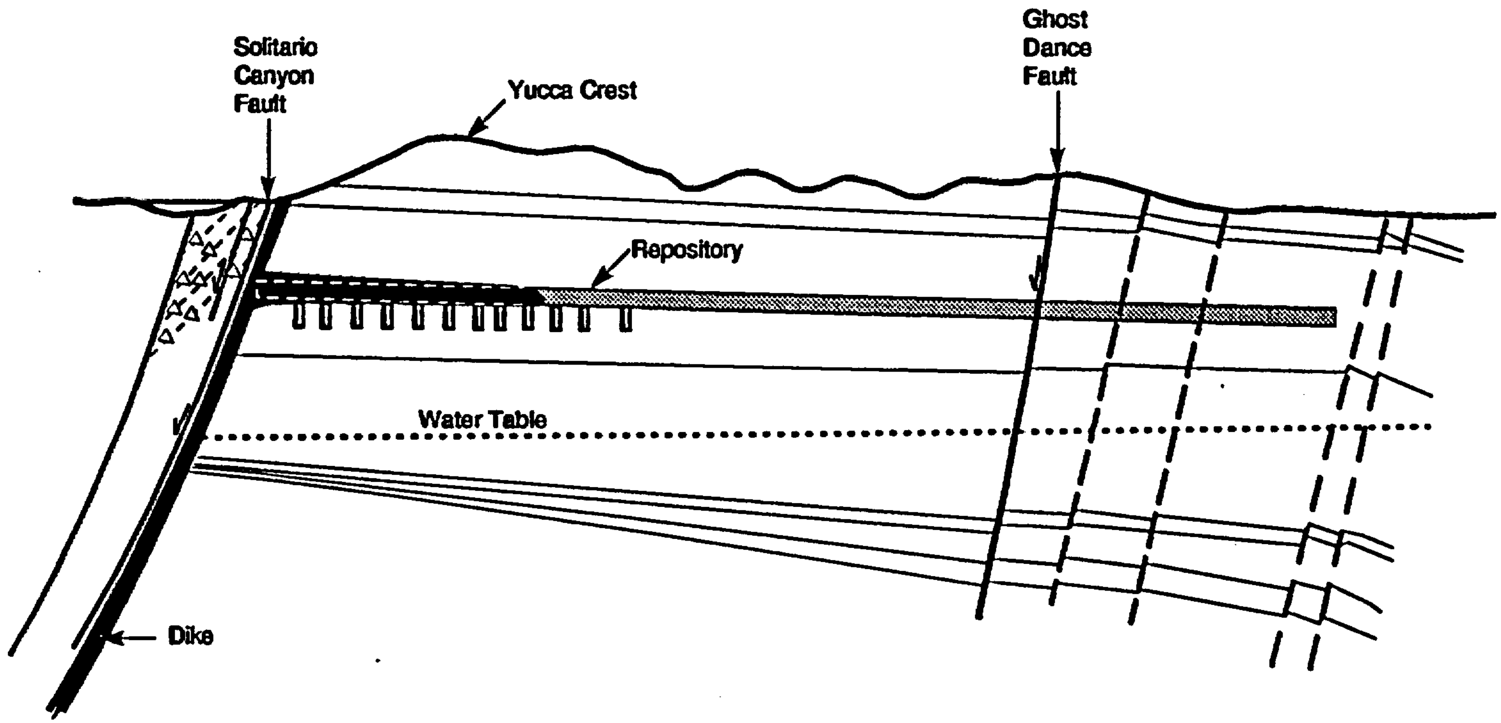


Tree Segment 12b. Scenario paths and scenario group paths of tree segment 12a.

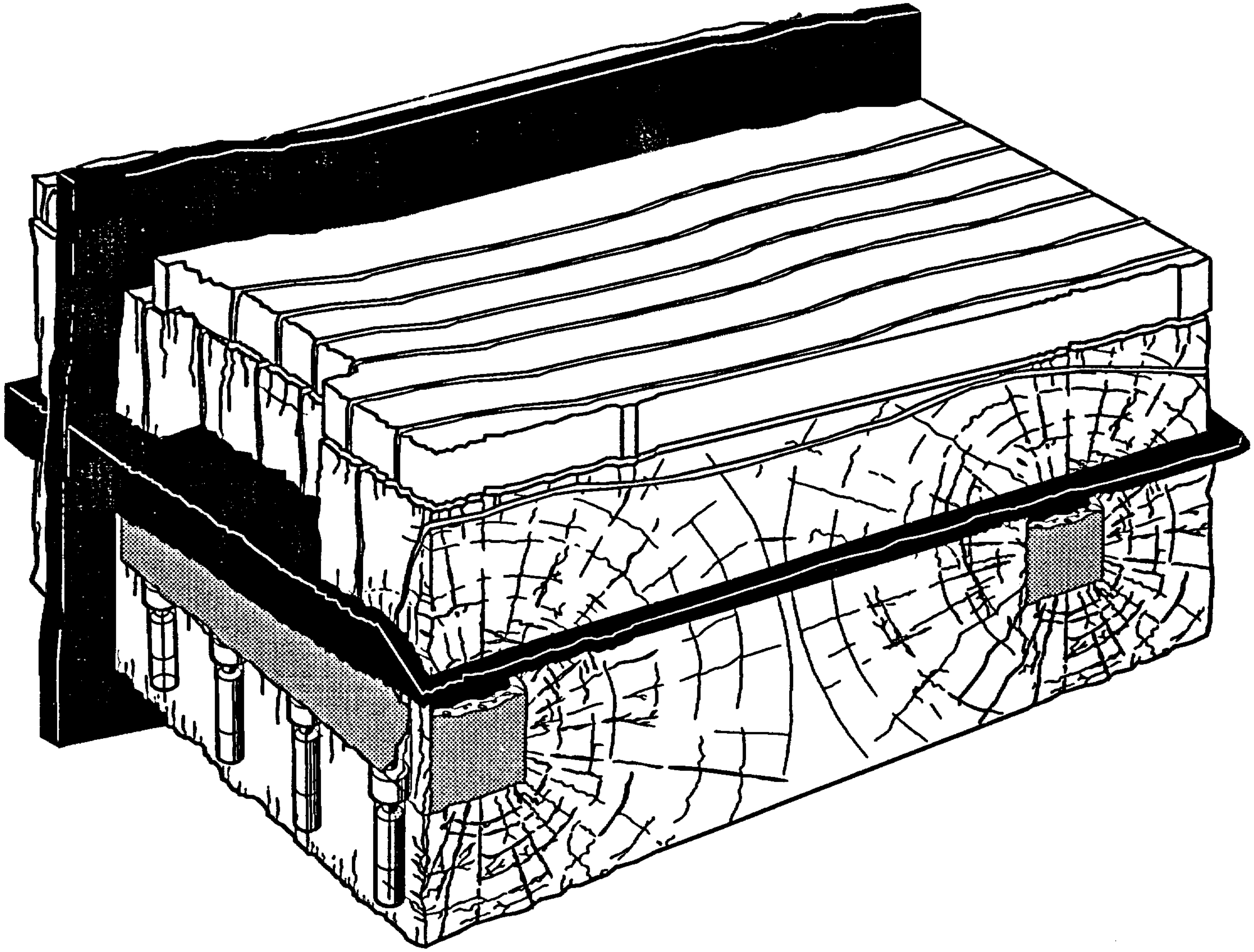
PRELIMINARY DRAFT



PRELIMINARY DRAFT



PRELIMINARY DRAFT



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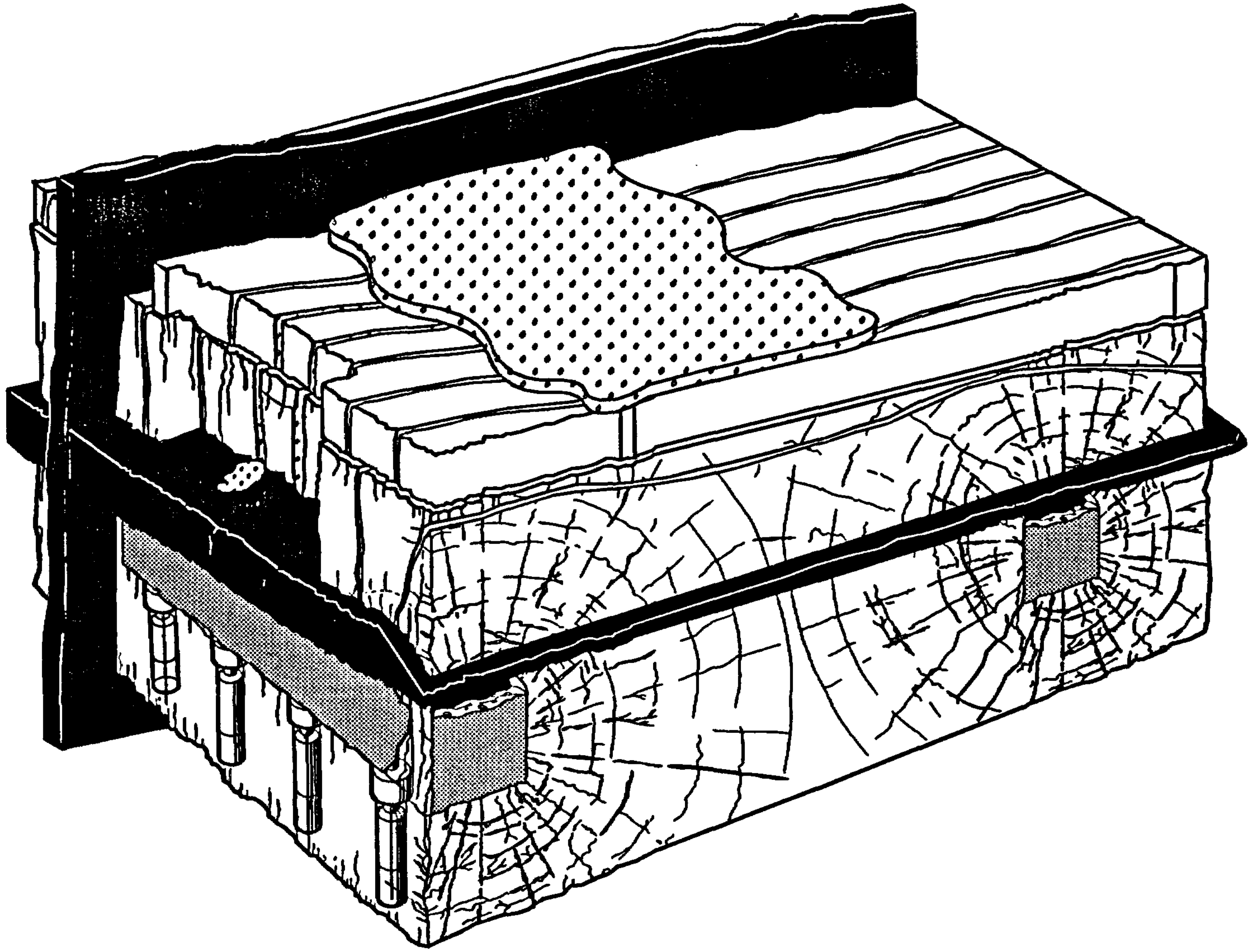

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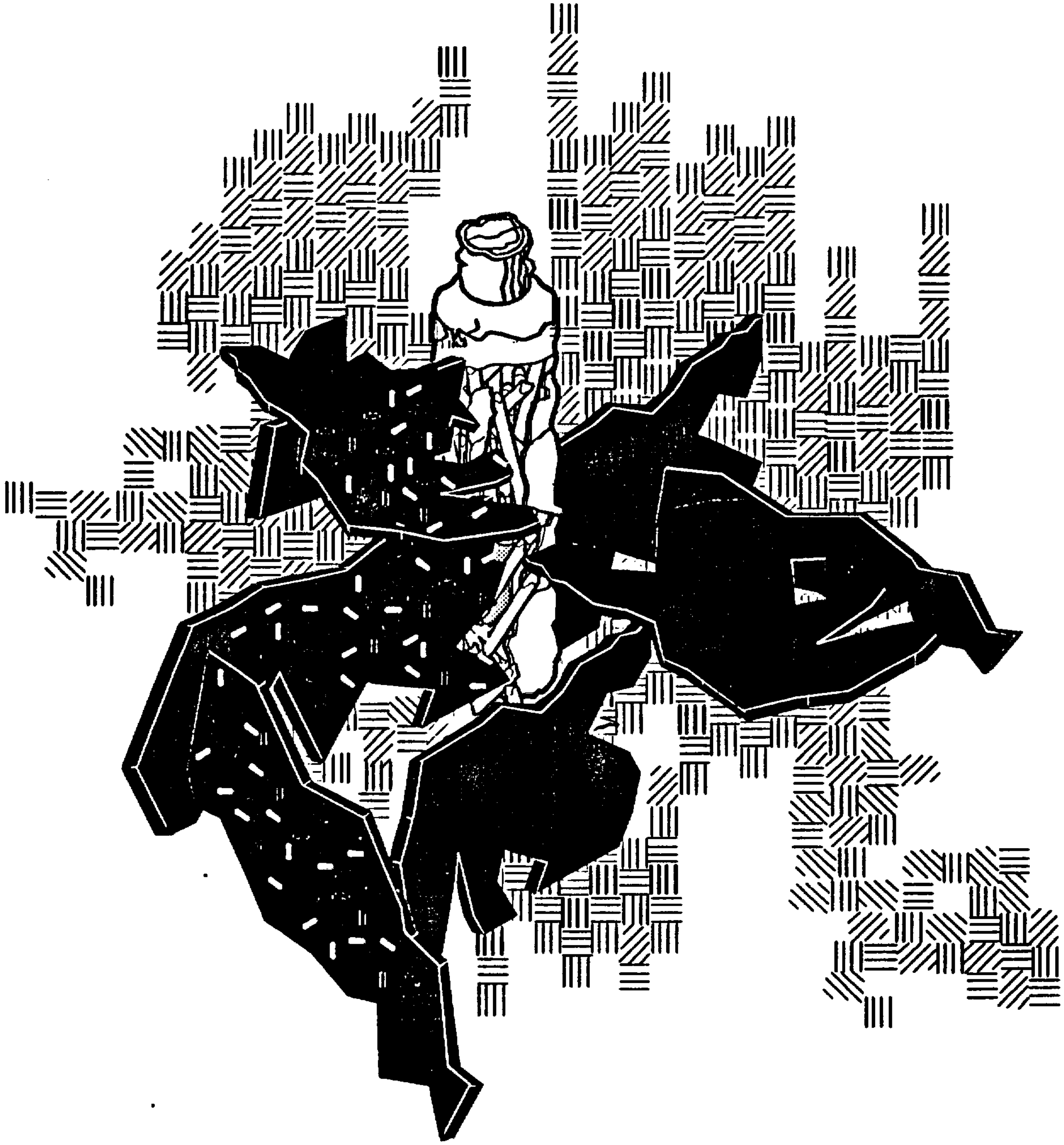

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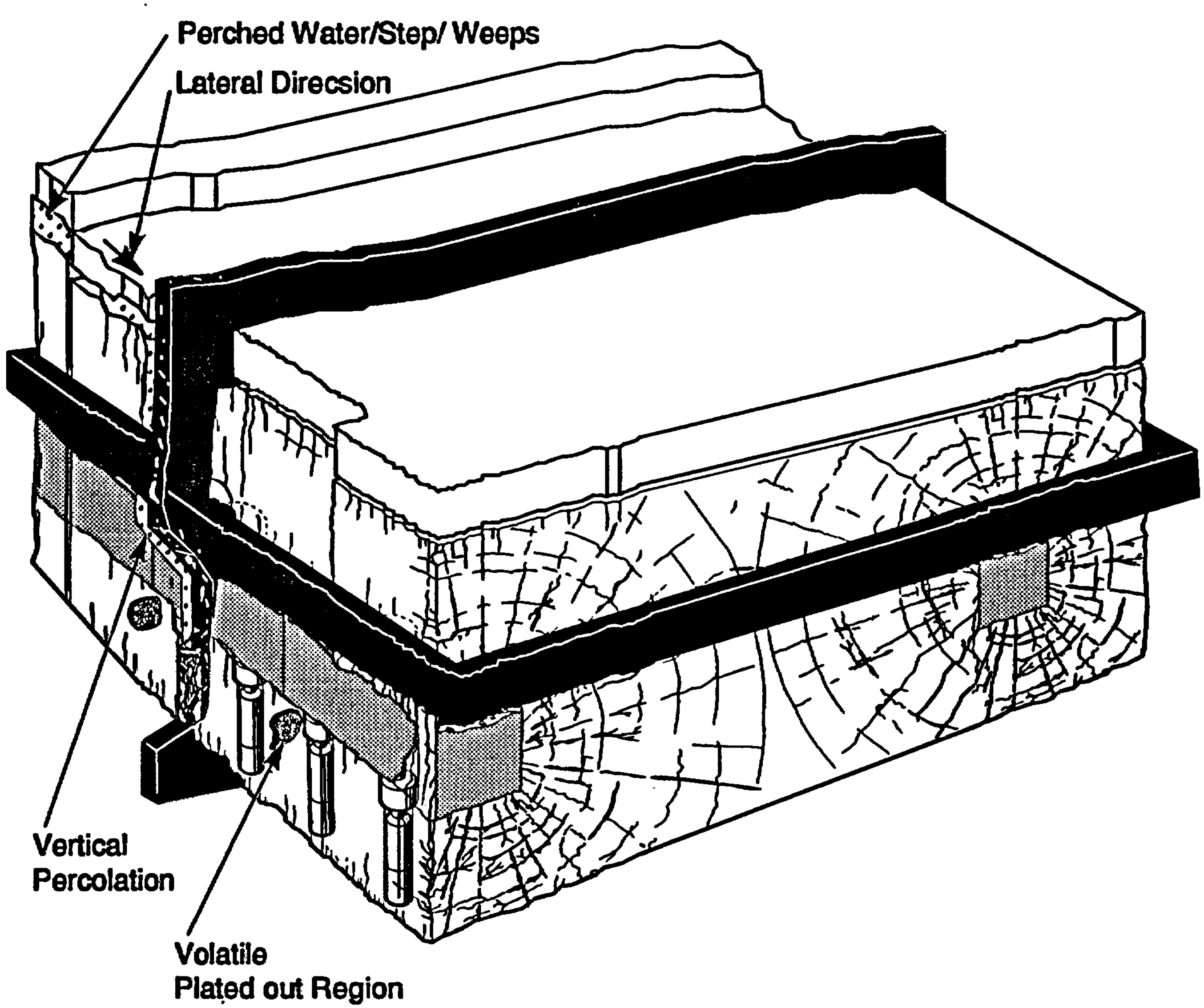
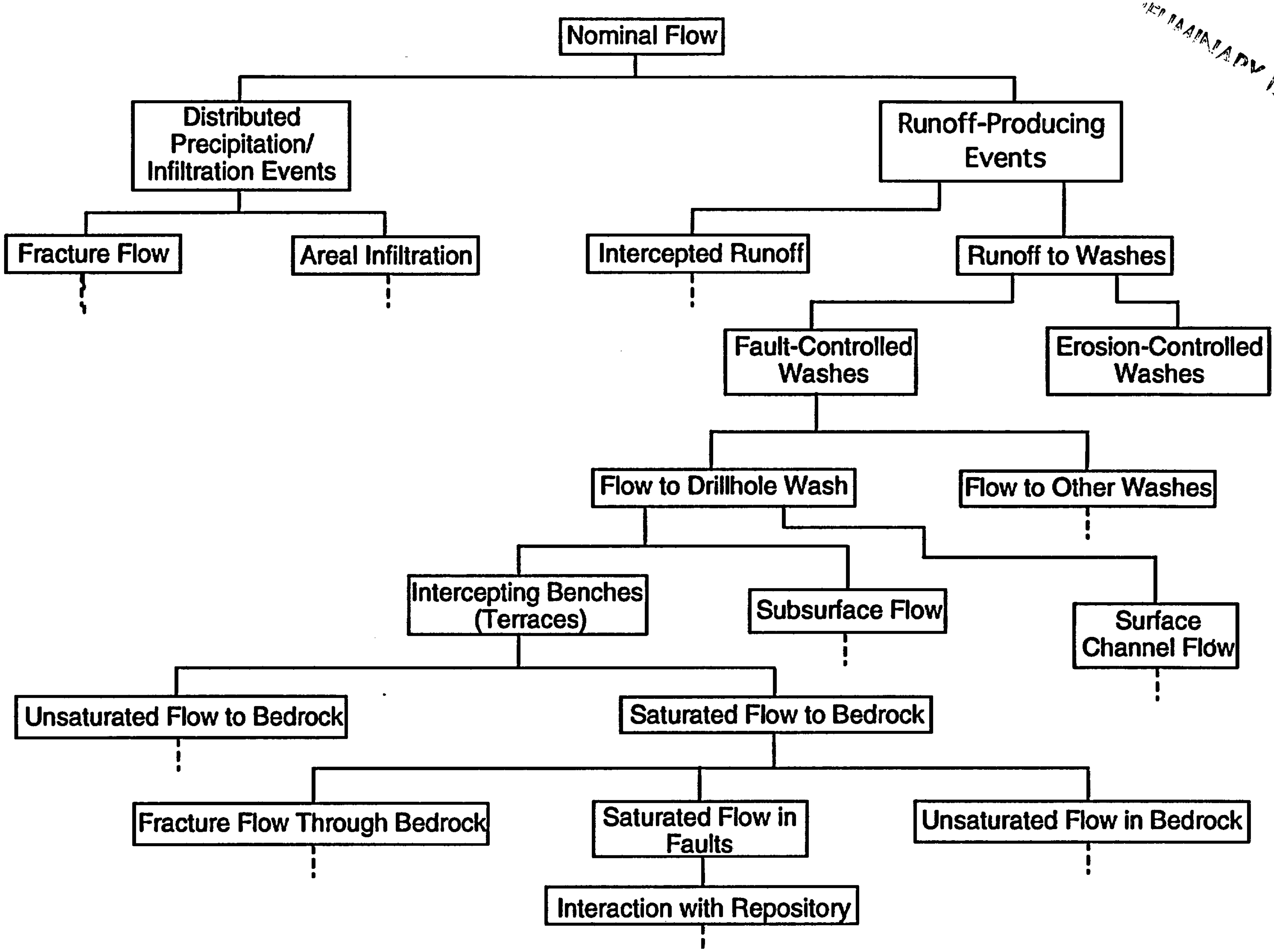
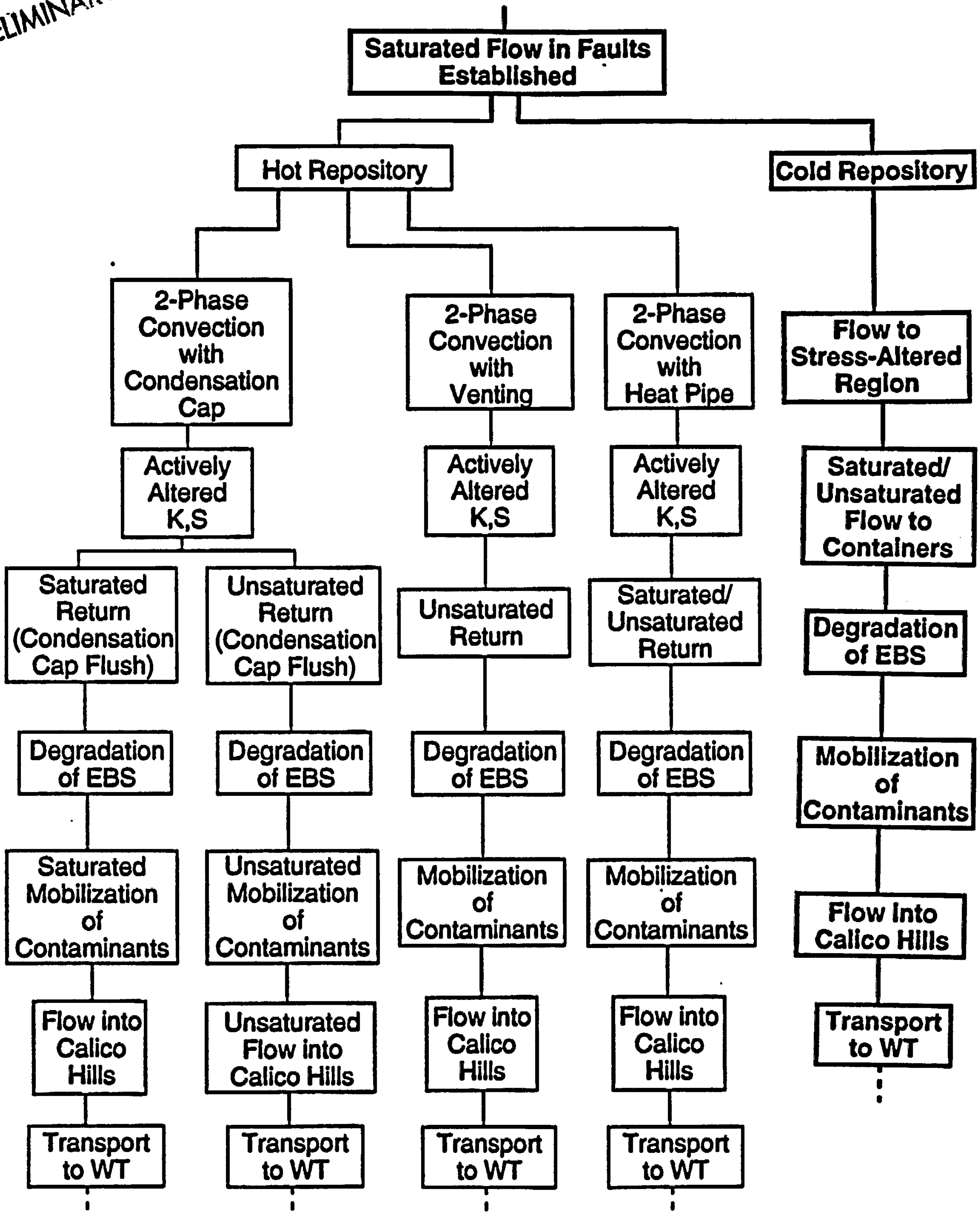


PRELIMINARY DRAFT


Nominal Flow
Distributed Precipitation/ Infiltration Events
Runoff-Producing Events
Fracture Flow
Areal Infiltration
Intercepted Runoff
Runoff to Washes
Fault-Controlled Washes
Erosion-Controlled Washes
Flow to Drillhole Wash
Flow to Other Washes
Intercepting Benches (Terraces)
Subsurface Flow
Surface Channel Flow
Unsaturated Flow to Bedrock
Saturated Flow to Bedrock
Fracture Flow Through Bedrock
Saturated Flow in Faults
Unsaturated Flow in Bedrock
Interaction with Repository

PRELIMINARY DR



U.S. NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS

PRESENTATION FOR NRC/DOE TECHNICAL EXCHANGE ON SCENARIOS AND CCDF CONSTRUCTION

SUBJECT: APPLICATION OF SANDIA SCENARIO SELECTION PROCEDURE IN IPA PHASE 2

PRESENTER: J.R. PARK

PRESENTER'S TITLE AND ORGANIZATION: SYSTEMS PERFORMANCE ANALYST
HYDROLOGY & SYSTEMS PERFORMANCE BRANCH
DIVISION OF HIGH-LEVEL WASTE MANAGEMENT
OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS
U.S. NUCLEAR REGULATORY COMMISSION

PRESENTER'S TELEPHONE NUMBER: (301) 504-2592

APRIL 28-29, 1992

ATTACHMENT 9

Steps in the Sandia Scenario Selection Procedure

1. Identify Potentially Disruptive Events and Processes
2. Classify Events and Processes
3. Screen Events and Processes
4. Combine Events and Processes to Form Scenarios
5. Screen Scenarios

Identification of Potentially Disruptive Events and Processes

- Site-specific
- Potentially disruptive to waste isolation
- Identified by experts in earth science and waste management fields
- As comprehensive and complete as possible

IAEA List of Phenomena Potentially Relevant to Release Scenarios for Waste Repositories (IAEA, 1981)

Natural Processes and Events

Climate change
Hydrology change
Sea level change
Denudation
Stream erosion
Glacial erosion
Flooding
Sedimentation
Diagenesis
Diapirism
Faulting/Seismicity
Geochemical changes

Fluid interactions
- Groundwater flow
- Dissolution
- Brine pockets

Magmatic activity
- Intrusive
- Extrusive

Uplift/Subsidence
- Orogenic
- Epeirogenic
- Isostatic

Undetected features
- Faults, shear zones
- Breccia pipes
- Lava tubes
- Intrusive dikes

Gas or brine pockets
Meteorite impacts

IAEA List of Phenomena Potentially Relevant to Release Scenarios for Waste Repositories (IAEA, 1981)

Human Activities

Undetected past intrusion
- Undiscovered boreholes
- Mine shafts

Improper design
- Shaft seal failure
- Exploration borehole seal failure

Improper operation
- Improper waste emplacement

Transport agent introduction
- Irrigation
- Reservoirs
- Intentional artificial groundwater recharge or withdrawl
- Chemical liquid waste disposal

Climate control

Large scale alteration of hydrology

Intentional intrusion
- War
- Sabotage
- Waste recovery

Inadvertant future intrusion
- Exploratory drilling
- Archeological exhumation
- Resource mining (mineral, water, hydrocarbon, geothermal, salt, etc.)

IAEA List of Phenomena Potentially Relevant to Release Scenarios for Waste Repositories (IAEA, 1981)

Waste and Repository Effects

Thermal effects
- Differential elastic response
- Non-elastic response
- Fluid pressure, density viscosity changese
- Fluid migration

Chemical effects
- Corrosion
- Waste package-rock interactions
- Gas generation
- Geochemical alterations

Mechanical effects
- Canister movement
- Local fracturing

Radiological effects
- Material property changes
- Radiolysis
- Decay product gas generation
- Nuclear criticality

Classification of Events and Processes

- Addresses completeness issue (iterative with Step 1)
- Provides initial organization for scenario development
- Proposed classification schemes:
  - Origin and physical characteristics (natural, human-induced, waste- or repository-induced)
  - Manner of influence on repository and geology (release phenomena vs. transport phenomena)

Screening of Events and Processes

- Criteria:
  - Physical reasonableness (site-specific)
  - Probability of significant release (consistent with regulations)
  - Potential consequences (i.e., effects of natural properties of the site)

Example Set of Events and Processes Identified Sandia Application of Procedure (NUREG/CR-1667)

- Borehole or shaft to repository
- Borehole or shaft through repository to lower sandstone
- U-tube to middle sandstone
- Dissolution cavity from middle sandstone to repository
- Withdrawal wells conpleted into middle sandstone downdip from repository
- Withdrawal wells completed into lower sandstone downdip from repository
- Low-conductivity fault or dike in lower sandstone downdip from repository
- Low-conductiivity fault or dike through both aquifers downdip from repository

Combination of Events and Processes Into Scenarios

- Use of "logic diagram" or similar device
- Numerous scenarios possible
- "Base case" scenario represents initial conceptualization of disposal system (site, underground facility, and emplaced waste)

Sandia Definition of a Scenario (NUREG/CR-1667)

A scenario is "a set of naturally occurring and/or human-induced conditions that represent realistic future states of the repository, geologic systems, and groundwater flow systems that could affect the release and transport of radionuclides from the repository to humans."

Scenario Screening

- Criteria:
  - Physical reasonableness (incompatible events and processses)
  - Probability of occurrence
  - Potential consequences (cumulative releases or health effects)

US NRC Application of Sandia Scenario Selection Procedure in IPA Phase 2

Purpose: To evaluate the procedure for potential use within the IPA effort

Status: Application in Phase 2 is currently incomplete. Potentially disruptive fundamental events and processes have been identified, classified, screened, and combined into scenario classes.

Products: A set of mutually exclusive scenario classes and scenarios, with corresponding probabilities, for use in the consequence analysis for IPA Phase 2.

Identification of Potentially Disruptive Events and Processes in IPA Phase 2

"System" definition:

- Boundaries are coincident with the Accessible Environment boundaries

- Phenomena operating within these boundaries (e.g., waste package corrosion, groundwater flow) are considered in the consequence models

- Phenomena initiated outside these boundaries (i.e., in the Accessible Environment) are included in the scenario analysis

Initial List of Fundamental Events and Processes for IPA Phase 2

I. Natural Events and Processes

A. Magmatic

1. Intrusive
2. Extrusive (volcanic)

B. Tectonic

1. Regional uplift
2. Regional subsidence
3. Seismicity
4. Faulting

C. Climatic

1. Current climate - extreme phenomena
2. Climate change

D. Other

1. Sea level changes
2. Tsunamis/seiches
3. Meteorite impact

Initial List of Fundamental Events and Processes for IPA Phase 2

II. Human-Initiated Events and Processes

A. Climate Control

B. War

C. Nuclear Weapon Testing at Nevada Test Site

D. Exploration/Exploitation Drilling for Natural Resources

E. Mining

1. Surface based (open pit)
2. Underground

F. Large-scale Alterations to Hydrology (e.g., dams)

Classification of Fundamental Events and Processes in IPA Phase 2

- Initial classification (and screening) imparted by definition of system boundaries

- Identified events and processes categorized as either natural or human-initiated

Screening of Fundamental Events and Processes in IPA Phase 2

- Initial screening imparted by definition of system boundaries
- Secondary screening used proposed Sandia criteria (i.e., physical reasonableness, probability of occurrence, and potential consequences)
- Combination of events and processes with similar types of consequences

Rationale for Screening of Fundamental Events and Processes in IPA Phase 2

Event or Process	Rationale
Regional uplift	Insignificant consequences
Regional subsidence	Insignificant consequences
Current climate - extreme phenomena	Subsumed under base-case conditions
Sea level change	Insignificant consequences
Tsunamis/Seiches	Not physically reasonable
Meteorite impact	Low probability of occurrence
Climate control	Subsumed under Climate change
War	Low probability of occurrence
Nuclear weapon testing at Nevada Test Site	Subsumed under Seismicity
Mining - surface based	Insignificant consequences
Mining - underground	Understanding of hazards
Large-scale alterations to hydrology	Low probability of occurrence

Final List of Fundamental Events and Processes for IPA Phase 2

I. Natural Events and Processes

   A. Magmatic

      1. Intrusive/Extrusive

   B. Tectonic

      1. Faulting/Seismicity

   C. Climatic

      1. Climate change

II. Human-Initiated Events and Processes

   A. Exploration/Exploitation Drilling for Natural Resources

Combination of Fundamental Events and Processes in IPA Phase 2

- Fundamental events and processes combined into scenario classes using "Latin square" diagram

- To cover probability space, "non-occurrence" of individual fundamental events and processes included in Latin square combinations

- Determination of probabilities for fundamental events and processes on-going. Screening of scenario classes to be based on assigned probabilities of occurrence

Scenario Definition for IPA Phase 2 Application of Sandia Scenario Selection Procedure

A "scenario" is a possible future sequence of processes and events that may alter the environment in which an HLW repository operates. Such processes and events may be naturally-occurring or human-initiated and may have effects on performance of the repository.

Combination of Events and Processes in IPA Phase 2 Using Latin Square

		$\bar{C}$		C	
		$\bar{D}$	D	$\bar{D}$	D
$\bar{M}$	$\bar{S}$	$\bar{M}\ \bar{S}\ \bar{D}\ \bar{C}$	$\bar{M}\ \bar{S}\ D\ \bar{C}$	$\bar{M}\ \bar{S}\ \bar{D}\ C$	$\bar{M}\ \bar{S}\ D\ C$
	S	$\bar{M}\ S\ \bar{D}\ \bar{C}$	$\bar{M}\ S\ D\ \bar{C}$	$\bar{M}\ S\ \bar{D}\ C$	$\bar{M}\ S\ D\ C$
M	$\bar{S}$	$M\ \bar{S}\ \bar{D}\ \bar{C}$	$M\ \bar{S}\ D\ \bar{C}$	$M\ \bar{S}\ \bar{D}\ C$	$M\ \bar{S}\ D\ C$
	S	$M\ S\ \bar{D}\ \bar{C}$	$M\ S\ D\ \bar{C}$	$M\ S\ \bar{D}\ C$	$M\ S\ D\ C$

KEY

$\bar{C}$ - No climate change

C - Climate change

$\bar{D}$ - No human intrusion from drilling

D - Human intrusion from drilling

$\bar{M}$ - No magmatism affecting the site

M - Magmatism affecting the site

$\bar{S}$ - No seismicity or fault movement affecting the site

S - Seismicity or fault movement affecting the site

Identified Concerns with the Sandia Scenario Selection Procedure

- Vague system definition

- Identified events and processes may not cover entire probability space (Sandia application)

- Screened events and processes, and associated probabilities, subsumed into base-case scenario (Sandia application)

Preliminary Draft

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

DOE/NRC Technical Exchange

Subject: Construction of CCDFs for Comparison with EPA's Cumulative Release Standard

Presenter: Paul W. Eslinger

Presenter's Title and Organization: Staff Scientist/Program Manager
Pacific Northwest Laboratory
Richland, Washington

Presenter's Telephone Number: (509) 376-2797

April 27-28, 1992

ATTACHMENT 10

Preliminary Draft

Problem Framework

- Perform the sequence of mathematical steps required to obtain the CCDF, G(M), of a performance measure M

  1. Specify the joint density function of all input variables
  2. Specify the mathematical form of release and transport models
  3. Obtain the density function, g(M), of the output performance measure
  4. Integrate g(M), and subtract from 1, to form G(M)

- Compare G(M) to the regulatory limits at the two points M=1 (probability of 0.9) and M=10 (probability of 0.999)

CCDF Estimation

- **The transformation to obtain an analytical form for the CCDF is mathematically intractable**
- **Numerical integration is required (Monte Carlo)**
  - Input space can be separated into "scenario classes"
  - Separate scenario classes will require separate models and/or computer codes

Preliminary Draft

Desirable Properties for the CCDF Estimator

Unbiased: $E[G_n(M)] = G(M)$

Consistent: $\lim_{n \to \infty} G_n(M) = G(M)$

Preliminary Draft

What is Compared to the Standard?

- Compliance is demonstrated if $G_n(M)$ is below the specified probabilities at the points M=1 and M=10

- No confidence interval on $G_n(M)$

How Many Samples are Enough?

- **The answer depends strongly on the location of the CCDF**
  - If $G_n(M)$ is close to the regulatory limit then many samples may be required
  - If $G_n(M)$ is far from the regulatory limit then fewer samples are required
- **Thought experiment - Given the observed set of computed results, what is the likelihood that the regulatory limits are violated?**
- **A rule of thumb for the number of samples required to achieve some predetermined width of a confidence interval may be useful**

Preliminary Draft

Considerations on Scenario Selection

- **Correlations among scenario classes must be evaluated in generating the CCDF**
- **The sum of probabilities for all scenarios must be unity**
- **Construct scenario classes by considering different processes (human intrusion, volcanism, etc.)**
- **Practical lesson: Account for as much uncertainty as possible in parameter variations, not scenarios**
  - Example: Model climate change within the nominal case framework by changing the pdf for the groundwater infiltration rate

Preliminary Draft

Combination of Scenario Results into an Overall CCDF

- **Several methods postulated, or in use**
  - SCP: A large number of scenario classes (EPPM's used for convenience)
  - WIPP: Each CCDF contains only a few points
  - EPRI: Event tree driven approach
  - NRC: Even different
  - Current TSPA: Two closely related techniques (PNL & SNL)

Preliminary Draft

Combination of Scenario Results into an Overall CCDF (Cont'd)

- **Current method**
  - A separate CCDF is produced for each scenario class
  - The combined CCDF is a linear combination of the separate CCDF's

$$G(m) = \sum_j G(M|S_j)P(S_j)$$

Where:

$G(M|S_j)$ is the conditional CCDF for scenario class j

$P(S_j)$ is the probability that scenario class j occurrs

U.S. NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS

PRESENTATION FOR NRC/DOE TECHNICAL EXCHANGE ON SCENARIOS AND CCDF CONSTRUCTION

SUBJECT: THE NRC STAFF'S ALTERNATIVE TO EPA'S HIGH-LEVEL WASTE STANDARDS

PRESENTER: S.M. COPLAN

PRESENTER'S TITLE AND ORGANIZATION: CHIEF, REPOSITORY PERFORMANCE ASSESSMENT SECTION
HYDROLOGY & SYSTEMS PERFORMANCE BRANCH
DIVISION OF HIGH-LEVEL WASTE MANAGEMENT
OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS
U.S. NUCLEAR REGULATORY COMMISSION

PRESENTER'S TELEPHONE NUMBER: (301) 504-2410

APRIL 28-29, 1992

ATTACHMENT 11

EPA'S 1985 STANDARDS

- Limit cumulative releases over 10,000 years from "all significant processes and events."
- Must be less than 1 chance in 10 of exceeding EPA's release limits.
- Must be less than 1 chance in 1,000 of exceeding ten times EPA's release limits.
- Requires CCDF incorporating all processes and events with probabilities greater than about one chance in 10,000.

NRC STAFF'S ALTERNATIVE

- Minimal changes from EPA's 1985 standards.
- Requires CCDF only for releases with more than one chance in 10 over 10,000 years.
- Less likely releases would be judged scenario by scenario, and would be limited to ten times EPA's release limits.
- A "scenario" is any process, event, or <u>sequence of processes and events</u> that is sufficiently credible to warrant consideration.

EVALUATING COMPLIANCE WITH EPA'S 1985 STANDARDS

1. Identify disruptive processes and events.
2. Screen processes and events.
3. Estimate probabilities and form scenarios.
4. Screen scenarios.
5. Estimate scenario releases.
6. Form CCDF.

EVALUATING COMPLIANCE WITH NRC STAFF'S ALTERNATIVE

1. Identify disruptive processes and events.
2. Screen processes and events.
3. Estimate probabilities for likely events and form scenarios.
4. Screen scenarios.
5. Estimate scenario releases.
6. Test releases for compliance.
7. Form CCDF only for likely releases.

SIMILARITIES IN THE TWO APPROACHES

- Identification of processes and events.
- Screening of processes and events.
- Formation of scenarios.
- Screening scenarios.
- Estimates of scenario releases.

DIFFERENCES IN THE NRC APPROACH

- Probability estimates for unlikely events.

  -No need for precision. Bounding estimate of <.01 is sufficient.

- Testing each scenario for compliance with 10X release limit.

- Formation of CCDF for likely releases only.

  -Includes scenarios with probabilities >.01.

IMPORTANT POINTS ABOUT THE NRC ALTERNATIVE

- 10X release limit applies to each scenario, or "sequence of processes and events."
- The total release due to <u>all</u> processes and events in a scenario is compared to the 10X release limit.
- Since all "sufficiently credible" scenarios are to be evaluated, repository performance can never cause releases greater than 10X.

IMPORTANT POINTS ABOUT THE NRC ALTERNATIVE (CONT'D)

- The probabilities of likely scenarios are estimated as in EPA's 1985 standards.
- Probabilities of unlikely scenarios are bounded by assigning $P<.01$ to unlikely processes and events.
- Therefore, the probability that releases will approach 10X is not known precisely.

IMPORTANT POINTS ABOUT THE NRC ALTERNATIVE (CONT'D)

- Assuming that "sufficiently credible" is interpreted as .001 to .0001, then:

  - NRC alternative would be <u>equally or more</u> stringent if <u>only a few</u> scenarios have releases approaching 10X.

  - NRC alternative would be <u>less</u> stringent if <u>many</u> scenarios have releases near 10X.

  - Both approaches reject any repository if releases greater than 10X are "sufficiently credible."

TREATMENT OF HUMAN INTRUSION

- Part 60 now classifies human intrusion as an "unanticipated" event.
- The NRC's alternative could classify HI as "unlikely," i.e., as $P < .01$.
- If so, only release estimates would be needed
- Implication would be greater optimism about the effectiveness of institutional controls than assumed by EPA in deriving the standard

SUMMARY AND CONCLUSIONS

- Precise probability estimates of .001 to .0001 are not meaningful.
- Any definition of "sufficiently credible" should recognize this imprecision.
- The stringency of NRC's alternative is site-specific, but is not significantly different from EPA's 1985 standards.
- Human intrusion is a separable issue that depends on the effectiveness of inst. controls.

PRELIMINARY DRAFT

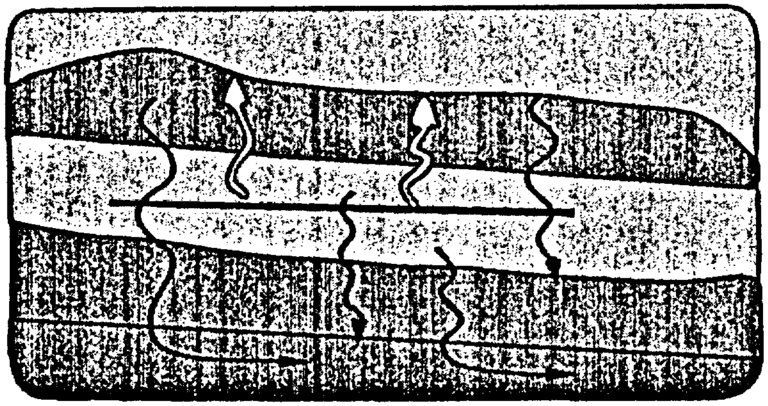
Example Application

Michael L. Wilson
Sandia National Laboratories

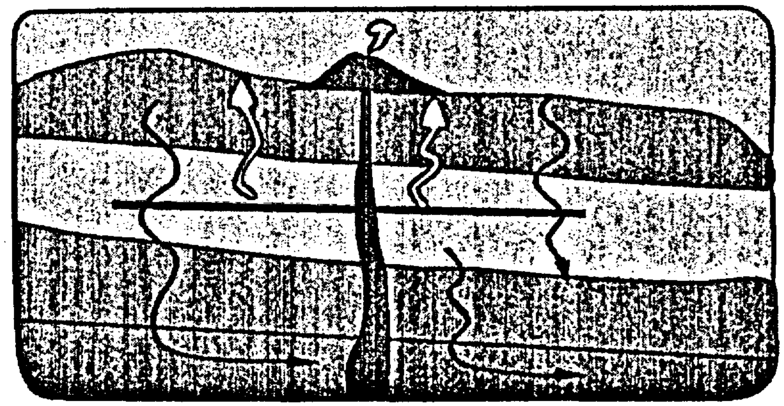
ATTACHMENT 12

PRELIMINARY DRAFT

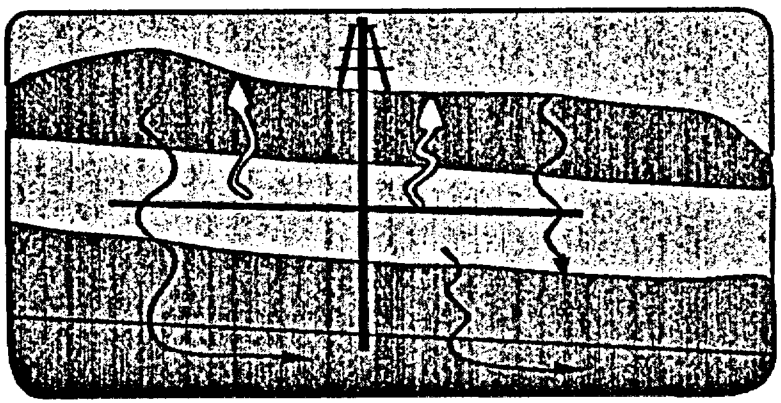
Conditions Modeled for Yucca Mountain



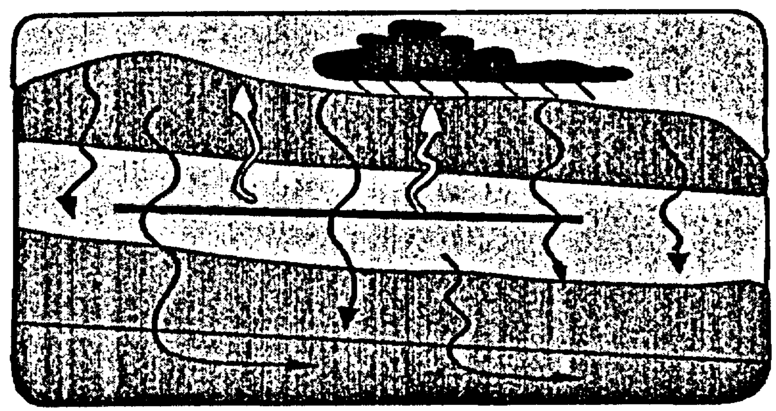
Undisturbed Conditions



Basaltic Volcanism



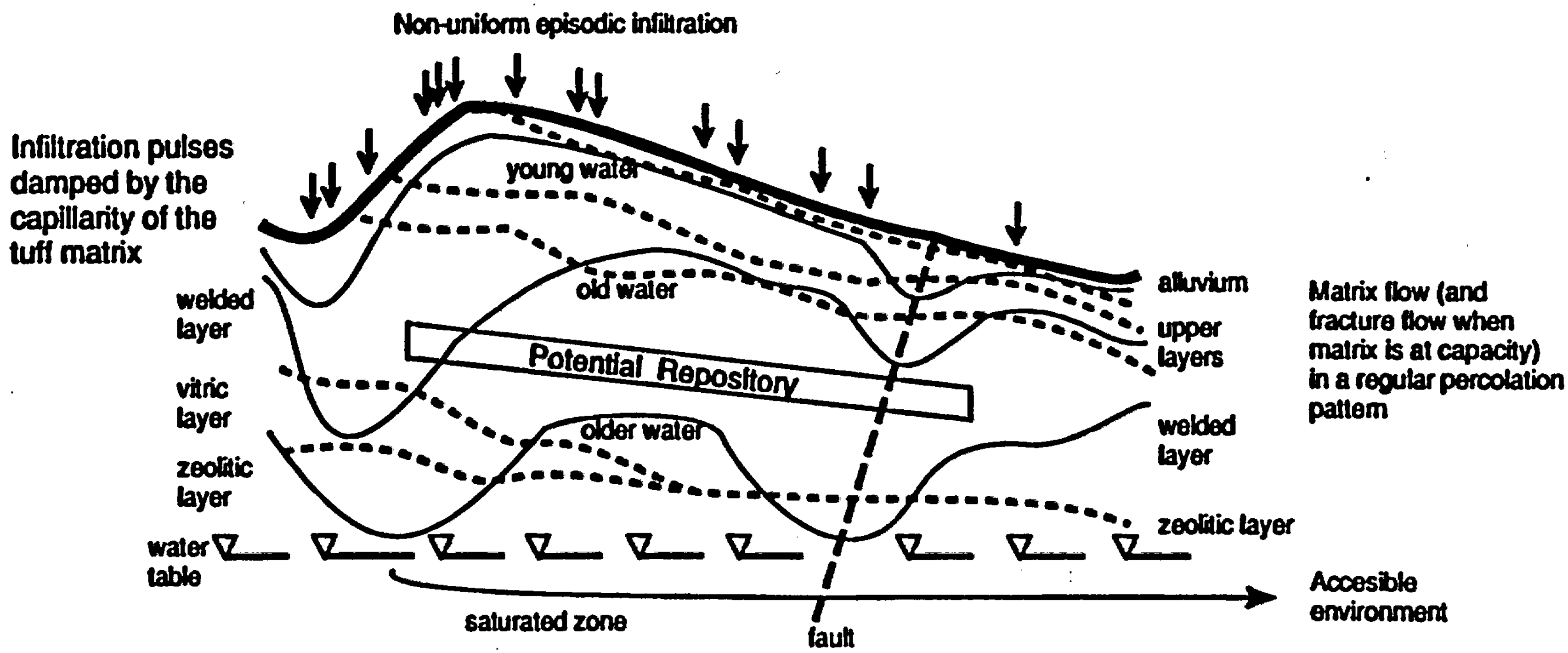
Human Intrusion



Climate Change

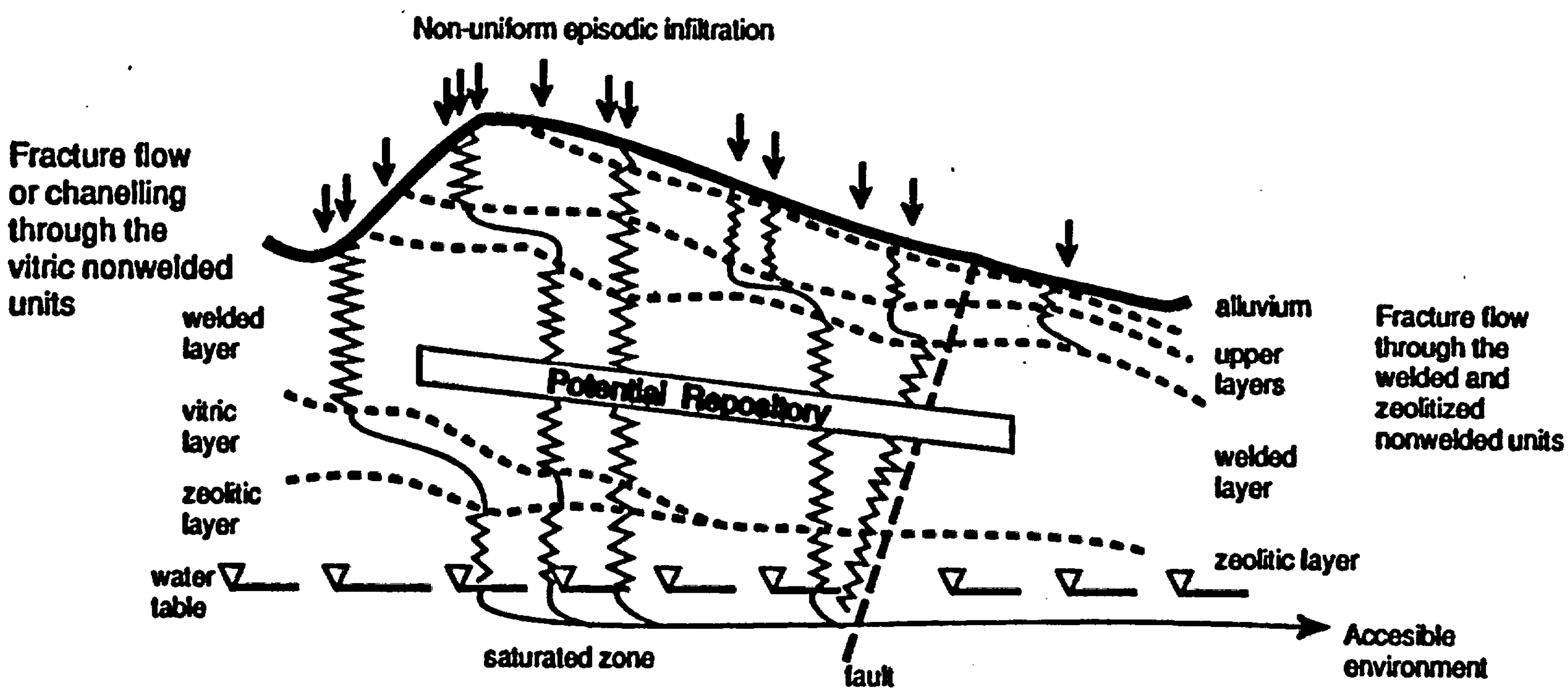
PRELIMINARY DRAFT

Composite-Porosity Model of Ground-water Flow



PRELIMINARY DRAFT

Weeps Model of Ground-water Flow



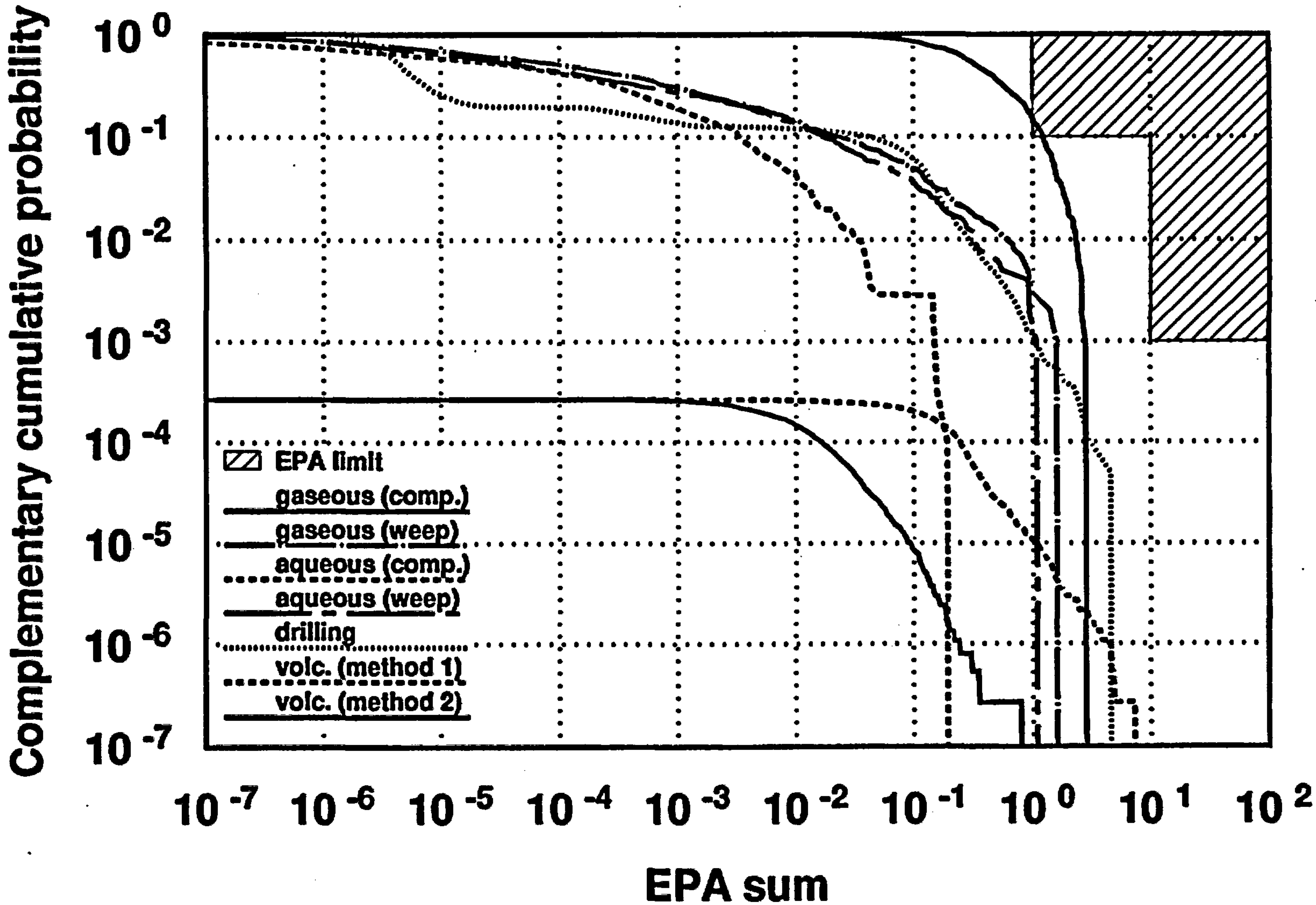
PRELIMINARY DRAFT

Sandia's 1991 TSPA

- The results are very preliminary.
- We did not attempt to be exhaustive—only a few representative scenarios were modeled.
- We made many simplifications, some of them quite conservative.
- We made a conscious effort to stress some parts of the system (e.g., high percolation fluxes).

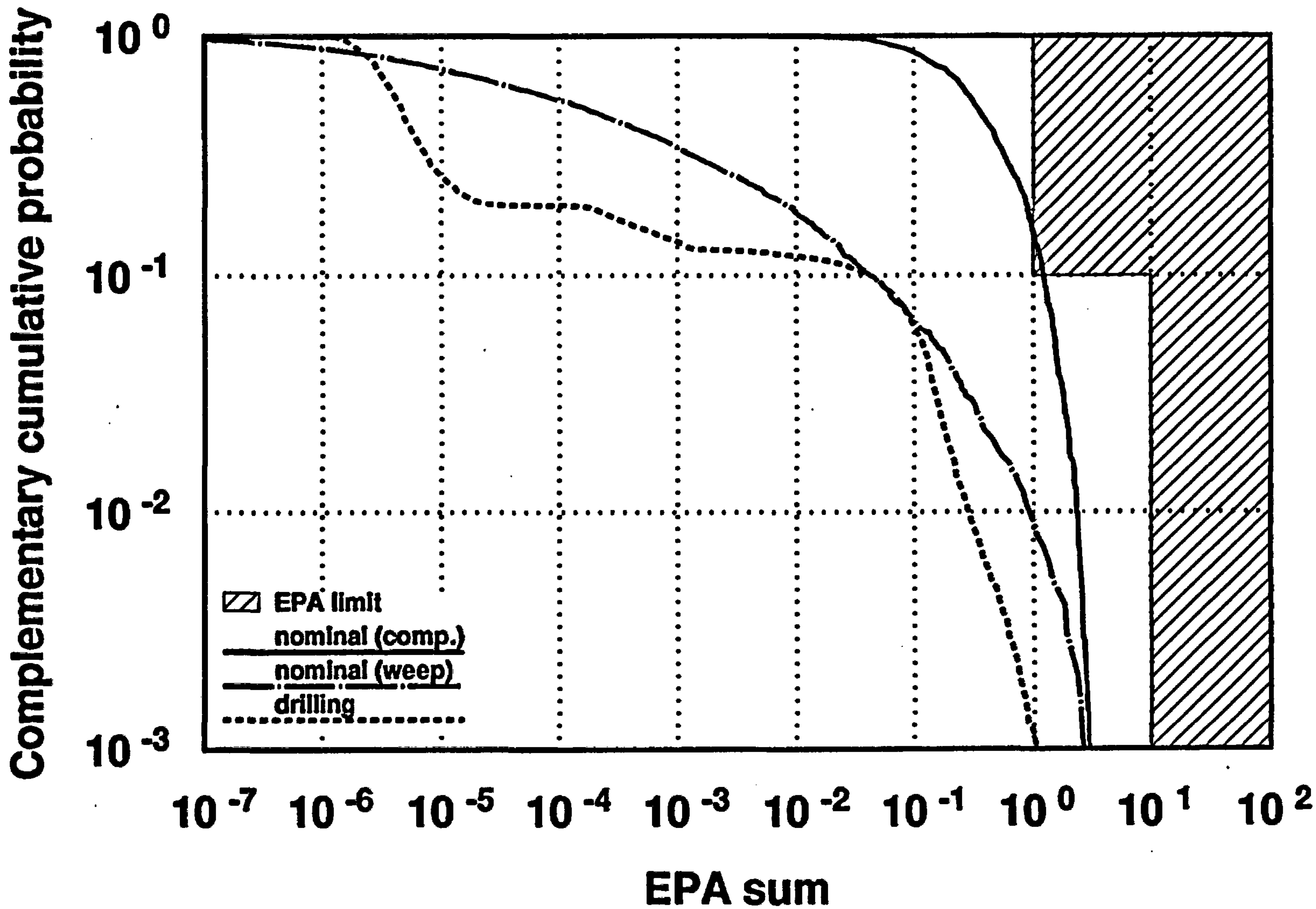
PRELIMINARY DRAFT

Conditional CCDFs for Sandia's 1991 TSPA

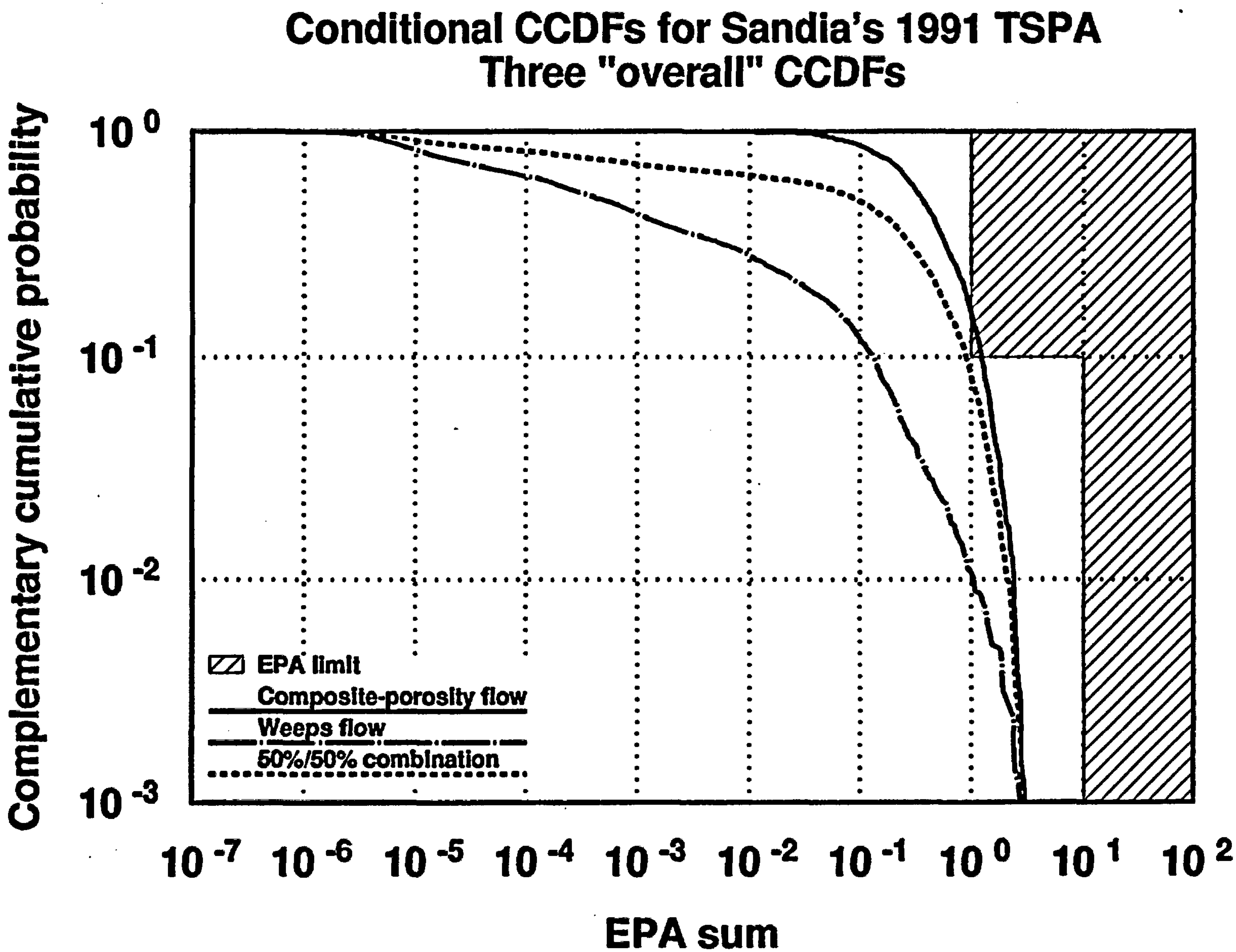


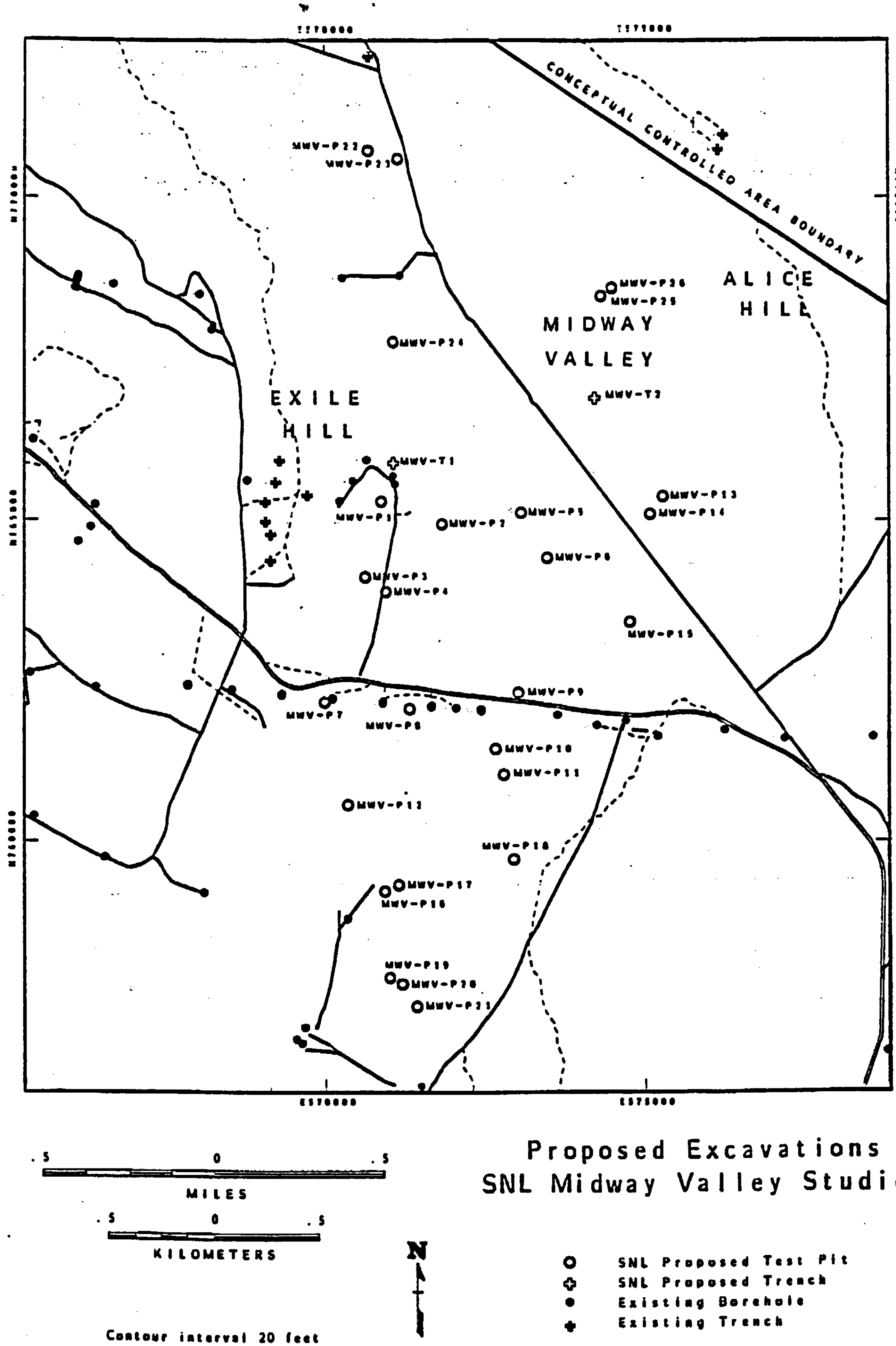
PRELIMINARY DRAFT

Conditional CCDFs for Sandia's 1991 TSPA (gaseous and aqueous combined)



PRELIMINARY DRAFT





Proposed Excavations
SNL Midway Valley Studies

EG&G YMP-91-03