

YUCCA
MOUNTAIN
PROJECT

Studies

Current Status of Feature, Event, and Process Screening and Scenario Selection for the Total System Performance Assessment - Site Recommendation

Presented to:
DOE/NRC Technical Exchange on
Total System Performance Assessment
San Antonio, Texas

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May 25 - 27, 1999



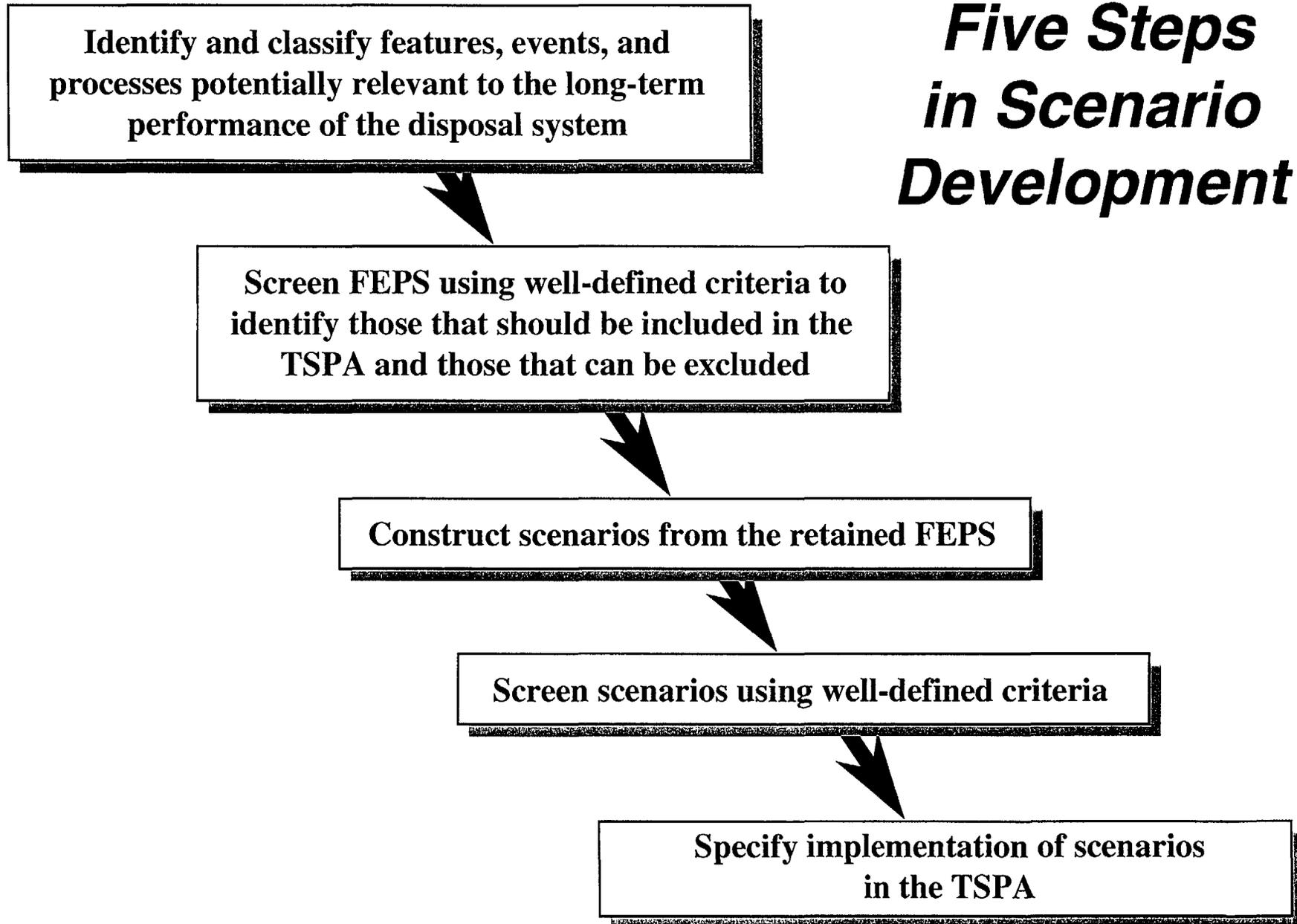
U.S. Department of Energy
Office of Civilian Radioactive
Waste Management

Geoffrey Freeze

Outline of Presentation

- **Summary of Yucca Mountain Project (YMP) Features, Events, and Processes (FEPs) Approach**
- **Current Status of FEP Database**
- **Structure for Completing FEP Screening**
- **Current Status of Scenario Selection**
- **Combining Scenario Results into the Overall Expected Annual Dose**
- **Conclusions**

Five Steps in Scenario Development



FEPs in Proposed 10 CFR Part 63

§ 63.2 Performance assessment means a probabilistic analysis that:

- (1) Identifies the features, events, and processes that might affect the performance of the geologic repository; and**
- (2) Examines the effects of such features, events, and processes on the performance of the geologic repository; and**
- (3) Estimates the expected annual dose to the average member of the critical group as a result of releases from the geologic repository**

FEPs in Proposed 10 CFR Part 63

(Continued)

§ 63.114 Any performance assessment shall...

- (d) Consider only events that have at least one chance in 10,000 of occurring over 10,000 years**
- (e) Provide the technical basis for either inclusion or exclusion of specific features, events and processes of the geologic setting. Specific features, events, and processes of the geologic setting must be evaluated in detail if the magnitude and time of the resulting expected annual dose would be significantly changed by their omission.**

FEPs in Proposed 10 CFR Part 63

(Continued)

§ 63.114 Any performance assessment shall...

- (f) Provide the technical basis for either inclusion or exclusion of degradation, deterioration, or alteration processes of engineered barriers in the performance assessment, including those processes that would adversely affect the performance of natural barriers. Degradation, deterioration, or alteration processes of engineered barriers must be evaluated in detail if the magnitude and time of the resulting expected annual dose would be significantly changed by their omission**

The Yucca Mountain Project FEP Database

- **Built from international lists and project documents**
 - organization is based on Organization for Economic Co-operation and Development (OECD)-Nuclear Energy Agency (NEA) draft list of 150 categories and 1261 FEPs
- **YMP list contains approximately 1800 entries**
 - ~ 450 are “primary” entries that need screening arguments
 - the rest are “secondary” entries that are retained for completeness and mapped to the primary entries

The Yucca Mountain Project FEP Database

(Continued)

- **Each FEP entry will include**
 - a description of the FEP
 - a summary of the screening argument (with references)
 - a summary of the TSPA disposition for retained FEPS (with references)
- **FEP Database functions as an annotated library catalog: technical basis for screening decisions resides in the supporting documentation**

Organization and Functionality of the FEP Database

- **Four first-order categories developed by the NEA**
 - **0.x.x Assessment Basis FEPs**
 - » FEPs related to the purpose and scope of the analysis
 - » Most 0.x FEPs for Yucca Mountain are resolved by regulation or policy
 - **1.x.x External FEPs**
 - » natural and human FEPs independent of the long-term behavior of the disposal system (e.g., long-term geologic processes, climate, human intrusion)
 - **2.x.x Disposal System Environment FEPs**
 - » FEPs that operate within the disposal system
 - **3.x.x Disposal System Radionuclide/Contaminant FEPs**
 - » FEPs related to radionuclide release/transport/exposure/dose

Organization and Functionality of the FEP Database

(Continued)

- **Maintained in both Claris Filemaker and Microsoft Access**
- **Electronic Form allows keyword searches, filters, and sorts within the database**
 - **Users can design their own searches**
 - **Direct links to primary reference documents are not available**

Draft Example Page from FEP Database

FEP Database								
File Edit Insert Records Window Help								
Apply Filter Last Filter New Filter Save Filter Retrieve Filter Back Forward Other Form Directory Exit								
ID	YMP FEP No.	NEA CATEGORY	FEP NUMBER	FEP NAME	PRIMARY/SECONDARY	SCREENING (INCLUDE/EXCLUDE)	WORKSHOP	OWNER(s)
	531	2.1.03ca	YM130	Cladding Degradation Before YMP Receives It	Primary entry		WF	V. Pasupathi (WF/Cladding)
	2.1.03.01.00							
	533	2.1.03cf	YM135	Cladding Degradation Mechanisms at YMP, Pre-	Secondary entry, see 2.1.03ch,cm		WF	V. Pasupathi (WF/Cladding)
	2.1.03.02.01							
	537	2.1.03cg	YM136	Corrosion (of cladding)	Secondary entry, see 2.1.03ch		WF	V. Pasupathi (WF/Cladding)
	2.1.03.02.02							
	538	2.1.03ch	YM137	General Corrosion (of cladding)	Primary entry	Exclude	DSNF,WF	V. Pasupathi (WF/Cladding)
	2.1.03.02.00							
	539	2.1.03ci	YM138	Microbial Corrosion (MIC) (of cladding)	Secondary entry, see 2.1.03ch	Exclude	DSNF,WF	V. Pasupathi (WF/Cladding)
	2.1.03.02.03							
	540	2.1.03cj	YM139	Acid Corrosion from Radiolysis (of cladding)	Secondary entry, see 2.1.03ch	Exclude (?)	DSNF,WF	V. Pasupathi (WF/Cladding)
	2.1.03.02.04							
	541	2.1.03ck	YM140	Localized Corrosion - Pitting (of cladding)	Secondary entry, see 2.1.03ch	Include	DSNF,WF	V. Pasupathi (WF/Cladding)
	2.1.03.02.05							
	542	2.1.03cl	YM141	Localized Corrosion - Crevice Corrosion (of	Secondary entry, see 2.1.03ch	Include	DSNF,WF	V. Pasupathi (WF/Cladding)
	2.1.03.02.06							
	543	2.1.03cm	YM142	Creep Rupture (of cladding)	Primary entry	Exclude	DSNF,WF	V. Pasupathi (WF/Cladding)
	2.1.03.04.00							

All text is draft

Draft Example Page from FEP Database

ID		NEA CATEGORY	FEP NUMBER	INTERNAL MAPPING
543		2.1.03cm	YM142	Primary entry
YMP FEP No.	FEP NAME	TIME(thermal/post-thermal)		
2.1.03.04.00	Creep Rupture (of cladding)	thermal & post-thermal		
LOCATION(UZ/EBS/SZ)	EBS	TYPE(nominal/disturbed)	NA	
FEP DESCRIPTION	<p>2.2 Creep Rupture - Produces single small perforation that releases fission gas and relieving stress. Occurs early, when temperatures are high. Independent of UFP integrity.</p> <p>Dependency: Time at elevated temperatures (YMP)</p>			
RELEVANCE	Relevant	SCREENING (INCLUDE/EXCLUDE)	Exclude	
SCREENING ARGUMENT	<p>Creep failure was postulated as the dominant failure mode for fuel in dry storage but has not been observed. DOE sponsored the development of a cladding creep rupture model by Chin and Gilbert (1989). This model was developed for studying temperature limits of cladding for interim storage of spent fuel, and is based on different theoretical failure mechanisms. The dominant failure mechanism is void formation and decohesion at grain boundaries. In earlier cladding failure analyses for the YMP, Santanam et al. (1992) and McCoy (1995) used the Chin model.</p>			
TSPA DISPOSITION	<p>Not an issue. Will contribute to cladding failure rates in some high temperature design alternatives such as rod consolidation. Current models are sufficient.</p>			
REFERENCE	<p>Numerous test and models for cladding creep <small>TSDR V1, Chapter 6, Section 6.3.4.1.5</small></p>			
WORKSHOP	MODIFIED BY	MODIFIED ON DATE	MODIFIED ON TIME	
DSNF,JWF	Al Schenker	3/31/99	1:41:33 PM	
OWNER(s)	NOTES			
V. Pasupathi (UFP/Cladding)				

All text is draft

Schedule for the TSPA-SR FEP Database

- **Present**
 - Developmental stage
- **July 1999: Rev. 0**
 - **Controlled Electronic Database (YAP-SV.1Q)**
 - **Will contain complete list of FEPs to date, mapping to Process Model Reports and Work Plans**
 - **Will not contain screening arguments**

Schedule for the TSPA-SR FEP Database

- **March 2000: Rev. 1.0**
 - **Will contain summaries of screening arguments referenced to completed analysis reports**
 - **Will be prepared and completed in parallel with Process Model Reports and TSPA-SR documentation**

Quality Assurance of the Features, Events, and Processes Database

- **Database developed under AP-3.10Q work plan**
 - **Checking and review of screening arguments within database is limited to verification that entries are consistent with the supporting technical documents**
 - **Technical checking and review of screening arguments occurs during preparation of the supporting technical documents**
 - » **subject matter experts retain ownership of the technical content**
- **Controlled database maintained under YAP-SV.1Q**

Current Status of FEP Screening and Scenario Selection

(Preliminary, Final Status TBD)

- **Volcanism and premature failure of the waste package are the only disruptive events retained for scenario selection**
- **Criticality will be screened out during the first 10,000 years on the basis of low probability**
- **Seismic rockfall will be treated in the nominal scenario**

Current Status of FEP Screening and Scenario Selection

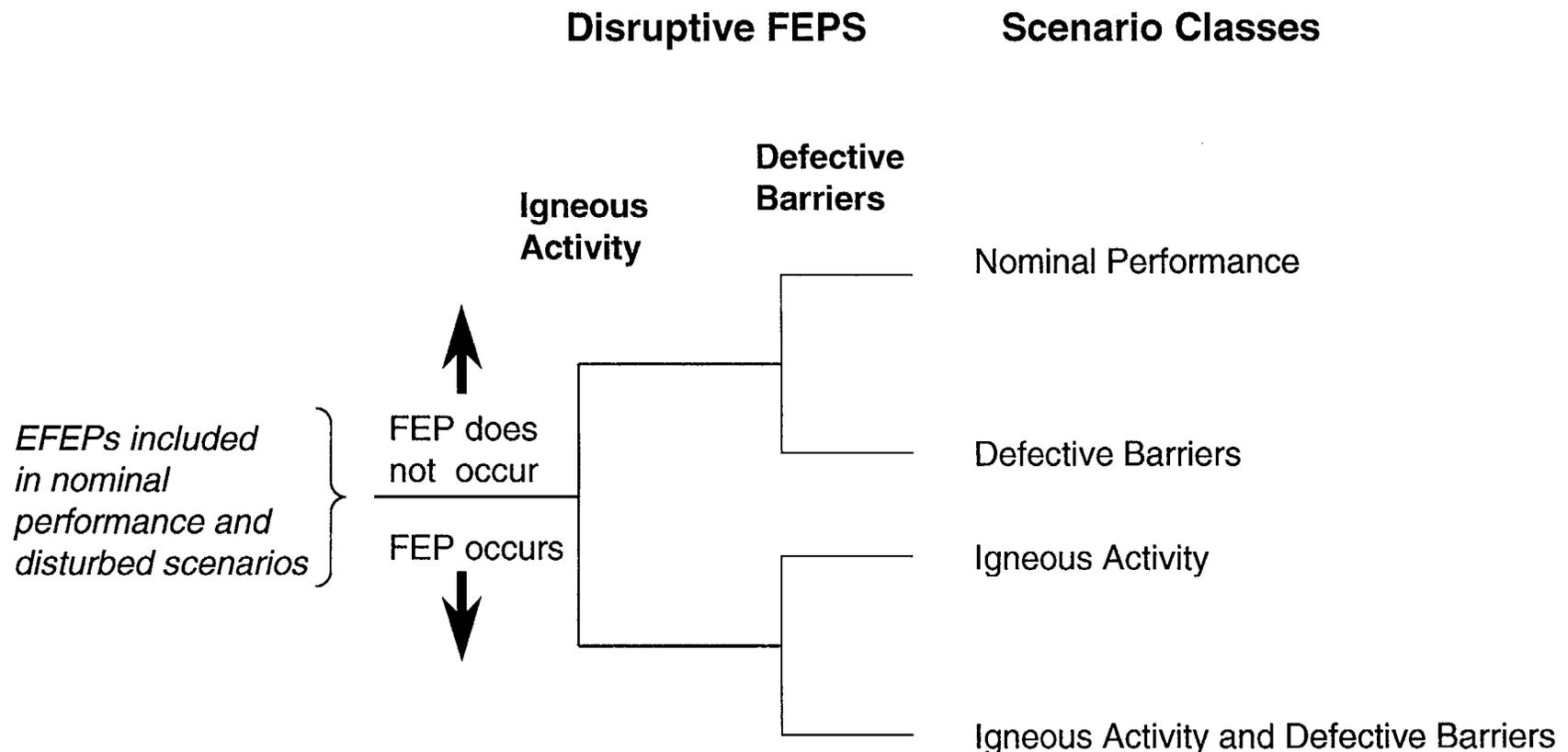
(Preliminary, Final Status TBD)

(Continued)

- **Other seismic effects (e.g., direct faulting, seismic pumping) will be screened out**
- **All other FEPs will either be included in the nominal scenario or screened out**
- **Human Intrusion is a special case**

Example Logic Diagram for Yucca Mountain

(consistent with the proposal of 5/4/99 to treat premature waste package failure as a possible consequence of initial defects in waste packages and drip shields)



Example Latin Square Diagram for Yucca Mountain

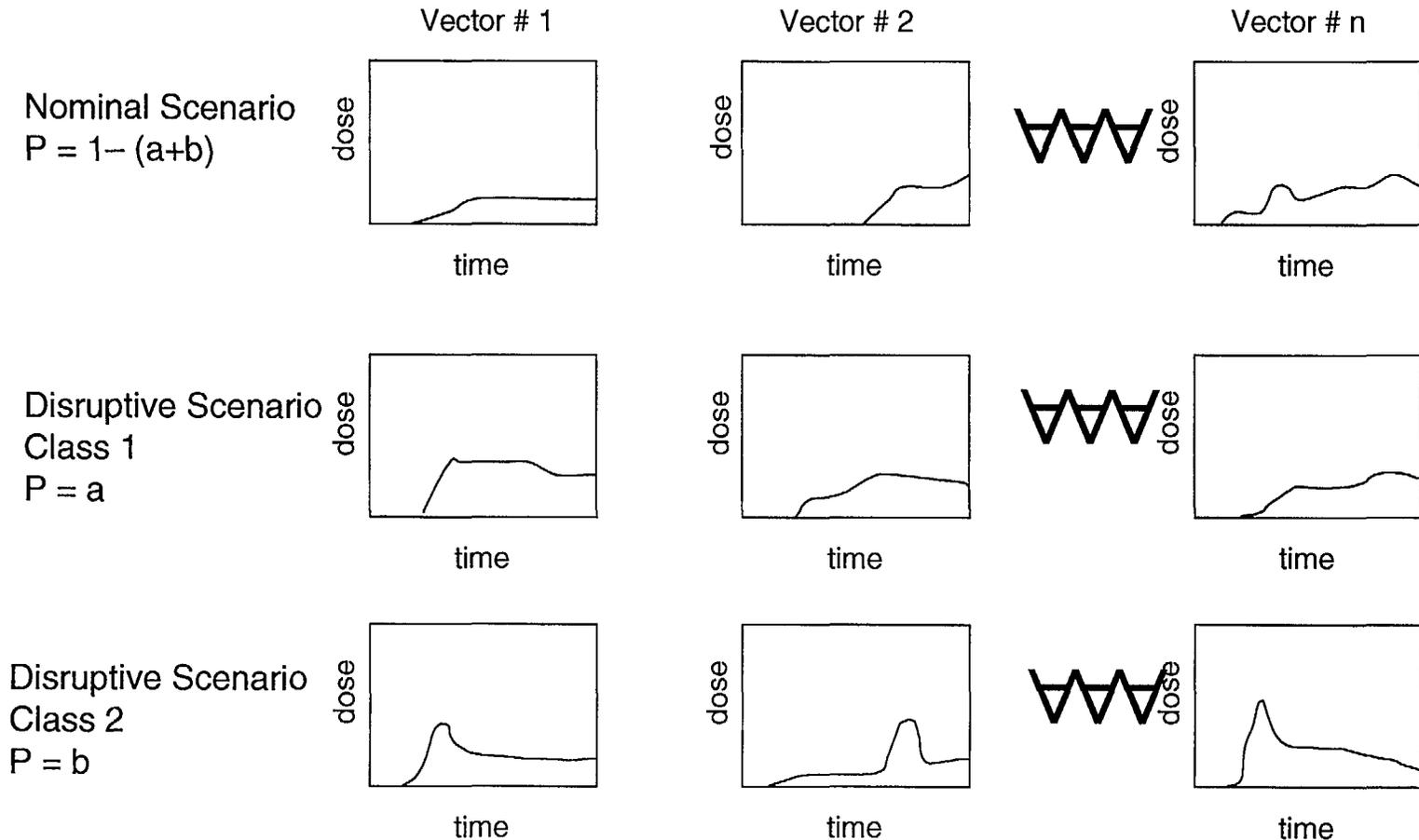
(consistent with the proposal of 5/4/99 to treat premature waste package failure as a possible consequence of initial defects in waste packages and drip shields)

	Defective Barriers Exist	Defective Barriers Do Not Exist
Igneous Activity Occurs	Igneous Activity and Defective Barriers	Igneous Activity
Igneous Activity Does Not Occur	Defective Barriers	Nominal Performance

Combining Results: Nominal and Disruptive Scenarios

- **Overall performance (i.e., the annual dose) is the weighted average (or distribution) of time histories for all scenario classes**
 - **includes probability-weighted consequences of all scenarios in the analysis**
 - **includes uncertainty from both Monte Carlo simulation and scenario probability assignment**

Example Calculation of Expected Annual Dose Curve



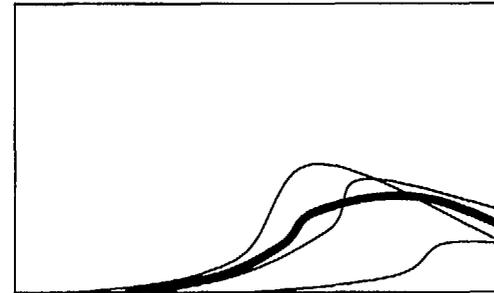
Overall expected dose curve calculated by averaging curves for each scenario class and then summing average curves for each scenario class weighted by scenario class probability

Example Display of Calculated Overall Performance Dose vs. Time

Nominal Scenario ($P = 0.99$)

Each curve represents a single Monte Carlo sample element

Each curve has equal weight

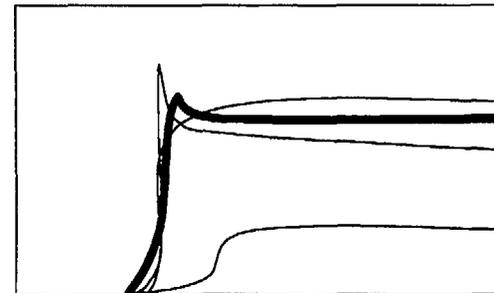


Disruptive Scenarios ($P = 0.01$)

(e.g., volcanic activity)

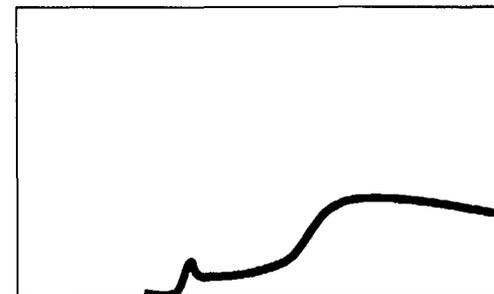
Each curve represents a subscenario

Each curve weighted by the subscenario probability



Overall Performance ($P = 1.00$)

Curve is the mean of the nominal and disturbed scenarios means, weighted by scenario probability



Summary of the Applications of the FEP Screening Process and the Database

- **Within the Yucca Mountain Project**
 - **FEP screening is the basis for selecting TSPA scenarios**
 - **FEP database verifies completeness of analysis by identifying outstanding issues**
 - **FEP database and screening process address NRC TSPA I IRSR Acceptance Criteria (Rev. 1.0, Section 4.4)**

Summary of the Applications of the Screening Process and the Database

- **For NRC and other reviewers**
 - **Documentation of the completeness of the analysis**
 - **Searchable electronic entry point into issue resolution--an annotated table of contents to technical issues**
 - **Links to specific IRSR issues can be built in**