QA: QA

TDR-WIS-MD-000003 REV 00 ICN 01

February 2001

The Development of Information Catalogued in REV00 of the YMP FEP Database

by

Geoff A. Freeze, Nancy S. Brodsky, and Peter N. Swift

Prepared for:
U.S. Department of Energy
Yucca Mountain Site Characterization Office
P.O. Box 30307
North Las Vegas, Nevada 89036-0307

Prepared by:
Bechtel SAIC Company, LLC
1180 Town Center Drive
Las Vegas, Nevada 89144

Under Contract Number
DE-AC08-01NV12101

Legacy Main - 70

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or any third party's use or the results of such use of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

The Development of Information Catalogued in REV00 of the YMP FEP Database

TDR-WIS-MD-000003 REV 00 ICN 01

February 2001

Prepared by:

Geoff Freeze — 2-28-01

Geoff Freeze
Originator

Date

Checked by:

WR HUNT
WR Hunt for John McCord — 2-28-01

John McCord
Checker

Date

Approved by:

Jerry A McNeish — 2·28·01

Jerry A McNeish
Responsible Manager, Total Systems Performance Department

Date

CHANGE HISTORY

Revision Number	Interim Change No.	Description of Change
0	0	Initial issue.
0	1	The U.S. Department of Energy issued a Technical Direction letter (Horton 2000) stating that the FEPs Database REV 00 ICN 00 was "accepted with conditions". REV 00 ICN 01 was developed to address those conditions. Specific conditions were addressed through: qualification of the database routines (but not the data) in accordance with AP-SI.1Q, *Software Management*; incorporation of changes and revisions to the FEP AMRs to consider the "no-backfill" design; incorporation of changes and revisions to the FEP AMRs to include criticality and other identified missing FEPs; and incorporation of changes and revisions to the FEP AMRs to address regulatory and legal comments made on Rev. 00 of the FEP AMRs.

CONTENTS

Page

1. INTRODUCTION 1

2. IDENTIFICATION OF THE YMP FEP LIST 5
   - 2.1 INTERNATIONAL FEPs 5
   - 2.2 YMP-SPECIFIC FEPs 6
   - 2.3 ITERATIVE CRWMS M&O REVIEW OF THE YMP FEP LIST 6
   - 2.4 EXTERNAL REVIEW OF THE YMP FEP LIST 8
   - 2.5 FUTURE DEVELOPMENT OF THE YMP FEP LIST 8

3. YMP FEP CLASSIFICATIONS 11
   - 3.1 DATABASE STRUCTURE 11
   - 3.2 PRIMARY AND SECONDARY FEPs 15
   - 3.3 ORGANIZATION AND NUMBERING OF DATABASE ENTRIES 17
   - 3.4 DATABASE FIELDS 17
   - 3.5 FUTURE DEVELOPMENT OF THE YMP FEP CLASSIFICATIONS 20

4. YMP FEP SCREENING DECISIONS AND SUPPORTING DOCUMENTATION 23
   - 4.1 SCREENING CRITERIA 23
   - 4.2 SCREENING GUIDELINES AND IMPLEMENTATION 24
   - 4.3 FUTURE DEVELOPMENT OF THE YMP FEP SCREENING DATA 25

5. DEVELOPMENT HISTORY OF YMP FEP DATABASE 27
   - 5.1 REV 00A 27
   - 5.2 REV 00B 27
   - 5.3 REV 00C 28
   - 5.4 REV 00 ICN 00 28
   - 5.5 REV 00 ICN 01 29

6. SUMMARY 31
   - 6.1 DISCUSSION OF AREAS OF DEFICIENCY RELEVANT TO NRC ACCEPTANCE CRITERIA 31

7. REFERENCES 35
   - 7.1 DOCUMENTS CITED 35
   - 7.2 CODES, STANDARDS, REGULATIONS, AND PROCEDURES 38

APPENDIX A - GLOSSARY A-1

APPENDIX B - MACHINE READABLE MEDIA ATTACHMENT - COMPACT DISC CONTAINING DATABASE AND SUPPLEMENTARY FILES FOR YMP FEPS DATABASE REV 00 ICN 01 ..... B-1

TABLES

1. FEP AMRs Contributing Screening Information to the YMP FEP Database REV 00 ICN 01 2
2. Origin of the 1261 FEPs in the NEA Database 5
3. Origin of the 292 FEPs Identified by a Review of YMP Literature 6
4. Origin of the 82 FEPs Identified at YMP Workshops Held Between December 1998 and April 1999 7
5. Origin of the 13 FEPs Identified in FEP AMRs 7
6. Origin of the 8 FEPs Identified in External Reviews 8
7. Hierarchical Structure of the YMP FEP Database REV 00 ICN 01 11
8. Abbreviations Used in Source Identifier Field 20

B-1. List of Files for YMP FEP Database REV 00 ICN 01 ..... B-1

ACKNOWLEDGEMENTS

DATABASE ROUTINE DEVELOPMENT

T. Ehrhorn, J. Danen

CHECKERS

J. McCord (Discipline Primary Checker), W.R. Hunt (PCG Lead)

TECHNICAL SUPPORT

L. Mays, M. Heerdt, M. Lee

INTENTIONALLY LEFT BLANK

ACRONYMS

AECL	Atomic Energy of Canada, Ltd.
AMR	Analysis Model Report
AP	Administrative Procedure
Bio, BIO	biosphere
CA	comparison approach
CRWMS	Civilian Radioactive Waste Management System
CSNF	commercial spent nuclear fuel
DE	disruptive events
DIRS	Document Input Reference System
DOE	U.S. Department of Energy
DSNF	Department of Energy spent nuclear fuel
EBS	engineered barrier system
FEP	feature, event, and process
FFC	far-field criticality
HMIP	Her Majesty Inspectorate of Pollution
IA	igneous activity
ICN	Interim Change Number
IDGE	in-drift geochemical environment
IRSR	Issue Resolution Status Report
ISC	in-situ criticality
KTI	Key Technical Issue
M&O	Management and Operating Contractor
MLD	master logic diagram
NAGRA	National Cooperative for the Disposal of Radioactive Waste (Nationale Genossenschaft Fur die Lagerung Radioaktiver Abfalle) (Switzerland)
NEA	Nuclear Energy Agency
NFC	near-field criticality
NFE	near-field environment
NRC	U.S. Nuclear Regulatory Commission
OECD	Organisation for Economic Cooperation and Development
QA	Quality Assurance
PMR	Process Model Report
QARD	Quality Assurance Requirements and Description
REV	Revision
REV 00	Revision 00
REV 00A	Revision 00A
REV 00B	Revision 00B
REV 00C	Revision 00C
REV 01	Revision 01
RSS	Repository Safety Strategy
SAM	Safety Assessment Management, Ltd.
SDS	structural deformation and seismicity
SKB	Svensk Karnbranslehantering AB (Swedish Nuclear Fuel and Waste Management Co.)

SKI	Swedish Nuclear Power Inspectorate
SYS	system-level
SZ	saturated zone
TH	thermal-hydrology
TSPA	Total System Performance Assessment
TSPAI	Total System Performance Assessment and Integration
TSPA-SR	Total System Performance Assessment for Site Recommendation
USFIC	unsaturated and saturated flow under isothermal conditions
UZ	unsaturated zone
WF	waste form
WF Misc	waste form - miscellaneous
WF Clad	waste form - cladding
WF Col	waste form - colloids
WIPP	Waste Isolation Pilot Plant
WP	waste package
YAP	Yucca Mountain Administrative Procedure
YMP	Yucca Mountain Project
YSCP	YMP Site Characterization Plan

1. INTRODUCTION

Under the provisions of the U.S. Department of Energy (DOE) Interim Guidance (Dyer 1999), a performance assessment is required to demonstrate compliance with the postclosure performance objectives for the Yucca Mountain Project (YMP). Dyer (1999, Section 102(j)) defines a performance assessment as a systematic analysis that (1) identifies the features, events, and processes (FEPs) that might affect the performance of the potential geologic repository, (2) examines the effects of such FEPs on the performance of the potential geologic repository, and (3) estimates the expected annual dose to a specified receptor group. The performance assessment must also provide the technical basis for inclusion or exclusion of specific FEPs in the performance assessment (Dyer 1999, Section 114). To address these requirements, the YMP has adopted a five-step approach to selecting scenarios for analysis in the Total System Performance Assessment for the Site Recommendation (TSPA-SR) that is based on the identification and screening of FEPs potentially relevant to the postclosure performance of the potential Yucca Mountain repository (CRWMS M&O 2000f, Section 2.1.1.1).

The purpose of this report is to document (a) the origin and development of a comprehensive list of FEPs potentially relevant to the postclosure performance of the repository, (b) the development, structure, and use of an electronic database capable of storing and retrieving information about the inclusion and/or exclusion of these FEPs in TSPA-SR, and (c) the status of YMP FEPs identification and screening activities for TSPA-SR relative to the areas of deficiency cited in the U.S. Nuclear Regulatory Commission (NRC) Total System Performance Assessment and Integration (TSPAI) Issue Resolution Status Report (IRSR) (NRC 2000, Section 5.2.2). This report and the associated database will also serve as a communication tool to assist reviewers during the site recommendation and license application processes.

The electronic YMP FEP Database REV 00 ICN 01 (Appendix B of this report) catalogs the YMP FEPs and their associated screening information, which are an integral part of the scenario analysis for TSPA-SR. The five-step scenario analysis approach for TSPA-SR is consistent with the five elements of the scenario analysis subissue outlined in the TSPAI IRSR (NRC 2000, Section 4.2). The five steps are:

1. Identification of FEPs
2. Classification of FEPs
3. Screening of FEPs
4. Formation of Scenario Classes
5. Screening of Scenario Classes

The YMP FEP Database REV 00 ICN 01 (Appendix B) contains the following information, which specifically addresses the first three steps of the scenario analysis approach (and correspondingly, the first three elements of TSPAI IRSR scenario analysis):

- <u>YMP FEP List</u> – A comprehensive list of FEPs that have the potential to influence repository performance.
- <u>FEP Classifications</u> – The categorization of FEPs in accordance with a hierarchical organizational structure that groups similar FEPs together and allows for relationships between FEPs to be identified.

- FEP Screening Decisions and Supporting Documentation - For each FEP, the technical basis for inclusion or exclusion in the TSPA-SR analyses is summarized as taken from FEP Analysis Model Reports (AMRs).

The information catalogued in the database, specifically the included (screened in) FEPs, provides the basis for scenario class formation and screening, the final two steps of the scenario analysis approach. However, these two steps (and correspondingly, the fourth and fifth elements of TSPAI IRSR scenario analysis) are outside the scope of the database, but are addressed in the TSPA-SR report (CRWMS M&O 2000f, Section 2.1.1.1).

All of the information in the database was developed external to the database. The origin and development of the YMP FEP list is described in Section 2 of this report. The development of the FEP classifications and the organizational structure of the database are described in Section 3. These two sections also contain discussions of future (i.e., subsequent to REV 00) enhancements. The FEP screening decisions and supporting documentation (collectively referred to as the screening discussions) were taken from FEP AMRs, listed in Table 1. Each FEP AMR was associated with a Process Model Report (PMR) subject area.

Table 1. FEP AMRs Contributing Screening Information to the YMP FEP Database REV 00 ICN 01

PMR Subject Area	FEP AMR DI	Reference
Unsaturated Zone Flow and Transport (UZ)	ANL-NBS-MD-000001 REV 01A	CRWMS M&O 2001e
Saturated Zone Flow and Transport (SZ)	ANL-NBS-MD-000002 REV 01	CRWMS M&O 2001c
Biosphere (Bio)	ANL-MGR-MD-000011 REV 01	CRWMS M&O 2001b
Disruptive Events (DE)	ANL-WIS-MD-000005 REV 00 ICN 01	CRWMS M&O 2000c
Waste Package Degradation (WP)	ANL-EBS-PA-000002 REV 01	CRWMS M&O 2001g
Waste Form Degradation (WF)		
- Miscellaneous FEPs (WF Misc)	ANL-WIS-MD-000009 REV 00 ICN 01	CRWMS M&O 2001h
- Cladding FEPs (WF Clad)	ANL-WIS-MD-000008 REV 00 ICN 01	CRWMS M&O 2000a
- Colloid FEPs (WF Col)	ANL-WIS-MD-000012 REV 00 ICN 01	CRWMS M&O 2001j
Near Field Environment (NFE)	ANL-NBS-MD-000004 REV 00 ICN 01	CRWMS M&O 2001d
Engineered Barrier System Degradation, Flow, and Transport (EBS)	ANL-WIS-PA-000002 REV 01	CRWMS M&O 2001a
System-Level and Criticality FEPs (SYS*)	ANL-WIS-MD-000019 REV 00	CRWMS M&O 2000d
* Not a PMR subject area.		

Each FEP AMR was prepared in accordance with AP-3.10Q, *Analyses and Models,* and provided qualified documentation of the screening decisions for each FEP relevant to the subject area. Technical details of specific screening discussions and screening criteria are documented in the FEP AMRs, not in this report. However, a general discussion of the nature of the screening discussions and future enhancements is presented in Section 4 of this report.

The YMP FEP Database REV 00 ICN 01 (Appendix B) evolved from REV 00 and from preliminary versions REV 00A, REV 00B, and REV 00C. The evolution of the database versions leading to REV 00 ICN 01 is described in more detail in Section 5 of this report.

A summary of the development and contents of the YMP FEP Database REV 00 ICN 01 is provided in Section 6. The summary section also discusses areas of deficiency for relevant NRC acceptance criteria, as identified in the TSPAI IRSR (NRC 2000, Section 5.2.2).

The Performance Assessment Operations responsible manager has evaluated this activity in accordance with AP-2.21Q, *Quality Determinations And Planning For Scientific, Engineering, And Regulatory Compliance Activities.* The activity evaluation for TSPA-SR (CRWMS M&O 2001i, Addendum A) has determined that the preparation and review of this technical report is subject to *Quality Assurance Requirements and Description* (QARD) DOE/RW-0333P (DOE 2000) requirements. A technical work plan for these activities (CRWMS M&O 2001i) was prepared, issued, and utilized in accordance with AP-2.21Q, *Quality Determinations And Planning For Scientific, Engineering, And Regulatory Compliance Activities.* This technical report was prepared in accordance with AP-3.11Q, *Technical Reports.*

An evaluation of the methods used to control the electronic management of data was performed as required by AP-SV.1Q, *Control of the Electronic Management of Information.* Specific process controls for this activity are outlined in the technical work plan (CRWMS M&O 2001i, Section 10 and Addendum B).

This document may be affected by technical product input information that requires confirmation. Any changes to the document that may occur as a result of completing the confirmation activities will be reflected in subsequent revisions. The status of the technical product input information quality may be confirmed by review of the DIRS database.

This technical report describes a database that catalogs technical information that was developed in supporting AMRs, but is not used to generate any new or independent technical information. Therefore, this technical report and the associated database will not affect the critical characteristics of the system and will not be directly relied upon to address safety or waste isolation issues.

INTENTIONALLY LEFT BLANK

2. IDENTIFICATION OF THE YMP FEP LIST

The development of a comprehensive list of FEPs potentially relevant to the postclosure performance of the potential Yucca Mountain repository is an ongoing, iterative process based on site-specific information, design, and regulations. The list of FEPs catalogued in the YMP FEP Database REV 00 ICN 01 (Appendix B) was developed using the following approach:

- Develop an initial list of general FEPs from other radioactive waste disposal programs.
- Supplement the general list with FEPs from project-specific literature.
- Augment the list through iterative discussion and review with CRWMS M&O subject matter experts (e.g., at technical workshops and in technical reports)
- Augment the list with feedback from external sources (e.g., NRC/DOE Technical Exchange and Appendix 7 Meetings, NRC IRSRs).

This approach combines the bottom-up (i.e., non-systematic, all-inclusive) identification of an initial FEP list with a top-down (i.e., systematic) series of reviews.

2.1 INTERNATIONAL FEPs

The YMP FEPs list was initially populated with 1261 FEPs compiled by other radioactive waste programs. The FEPs were taken from Version 1.0 of an electronic FEP database (Safety Assessment Management (SAM) 1997) maintained by the Nuclear Energy Agency (NEA) of the Organisation for Economic Co-Operation and Development (OECD). The NEA database contains FEPs from seven programs, and is the most complete attempt internationally at compiling a comprehensive list of FEPs potentially relevant to radioactive waste disposal. Consistent with the diverse backgrounds of the waste disposal programs contributing to the NEA list, FEPs were identified by a variety of methods, including expert judgment, informal elicitation, event tree analysis, stakeholder review, and regulatory stipulation.

Version 1.0 of the NEA database exists in draft form only. It contains extensive descriptions of potentially relevant FEPs from each of the seven programs along with program-specific technical discussions regarding their applicability. The YMP FEPs list includes the relevant portions of each of the NEA FEPs, but does not include the program-specific details unless they are also relevant to YMP. SAM (1997, Section 2.3) identifies the publications listed in Table 2 as the basis for the NEA FEPs. However, in many cases the draft NEA database contains more extensive FEP descriptions than the supporting publications. The number of FEPs in the database from each of these international programs is also listed in Table 2.

Table 2. Origin of the 1261 FEPs in the NEA Database

Nation	Organization	Type of Study	Number of FEPs (*)	Reference
Canada	Atomic Energy of Canada, Ltd. (AECL)	Scenario Analysis	281	Goodwin et al. 1994, Section 4.1 and App. B
International	Nuclear Energy Agency (NEA)	Scenario Working Group	146	NEA 1992, Chapter 4

Table 2. Origin of the 1261 FEPs in the NEA Database (cont.)

Nation	Organization	Type of Study	Number of FEPs (*)	Reference
Sweden	Swedish Nuclear Power Inspectorate (SKI)	SITE-94	106	Chapman et al. 1995
Sweden	Joint – SKI and Swedish Nuclear Fuel and Waste Management Co. (SKB)	Scenario Development	158	Andersson et al. 1989, App. A2 and B
United Kingdom	Her Majesty's Inspectorate of Pollution (HMIP)	Intermediate and low-level waste disposal	79	Miller and Chapman 1993
Switzerland	National Cooperative for the Disposal of Radioactive Waste (NAGRA)	Kristallin-1	245	NAGRA 1994, Chapter 4
United States	DOE Waste Isolation Pilot Plant (WIPP)	Compliance Application	246	DOE 1996, Sections 6.2, 6.3 and App. SCR

* These include FEPs from both the cited reference and the draft NEA database.

2.2 YMP-SPECIFIC FEPS

The 1261 NEA FEPs in the YMP FEP list were supplemented with 292 YMP-specific FEPs identified in a search of YMP literature (Barr 1999). Because the YMP is the only potential repository proposed for an unsaturated fractured tuff, many of these FEPs represent events and processes not otherwise included in the international compilation. The 1988 Site Characterization Plan (DOE 1988, Volume VII, Part B, Section 8.3.5.13) itemized 99 specific issues, from which 91 YMP-specific FEPs were identified. The other 8 issues were considered to be better captured or subsumed in other similar, but more broadly defined, FEPs. Other project documents provided the general basis for 201 additional YMP-specific FEPs as described in Barr (1999). The origins of the 292 YMP-specific FEPs are summarized in Table 3.

Table 3. Origin of the 292 FEPs Identified by a Review of YMP Literature

Source Document	Number of FEPs	Reference
YMP Site Characterization Plan (YSCP)	91	DOE 1988, Volume VII, Part B, Section 8.3.5.13
Other YMP Documents	201	Barr 1999

2.3 ITERATIVE CRWMS M&O REVIEW OF THE YMP FEP LIST

The resulting YMP list of 1553 FEPs identified from the NEA database and YMP literature was taken to a series of technical workshops convened between December 1998 and April 1999 (Table 4). At these workshops, the FEPs relevant to each subject area were reviewed and discussed by subject matter experts within the project. During these reviews and the associated intensive discussions, workshop participants identified 82 additional YMP-specific FEPs, as summarized in Table 4. Workshop participants also proposed several issues that were related to FEPs already in the database, in which case the existing FEP descriptions were expanded to include the new issues.

Table 4. Origin of the 82 FEPs Identified at YMP Workshops Held Between December 1998 and April 1999

Workshop	Date	Number of FEPs	Reference
Unsaturated-Zone Flow and Transport (UZ)	Dec. 14-16, 1998	0	**
DOE Spent Nuclear Fuel FEPs (DSNF)	Jan. 19, 1999	40	Eide 2000, Tables 1 and 2
Waste Form (WF)	Feb. 2-4, 1999	12	*
Disruptive Events (DE)	Feb. 9-11, 1999	18 6	CRWMS M&O 1998, Section 3.1 *
Saturated Zone Flow/Transport and Biosphere (SZ/Bio)	Feb. 17-19, 1999	1	*
Thermal Hydrology and Coupled Processes (TH)	Mar. 24-25, 1999	1	*
In-Drift Geochemical Environment and EBS Transport (IDGE/EBS)	Apr. 13-15, 1999	2	*
Waste Package Degradation (WP)	Apr. 20-21, 1999	2	*

* Indicates that new FEPs were generated by roundtable discussion and subsequently entered directly into database.

** Indicates that no new FEPs were generated at this workshop.

Except for the 40 FEPs from the DSNF Workshop and 18 criticality-related FEPs from the DE Workshop, these additional YMP-specific FEPs were developed informally during roundtable discussions at the workshops and have no formal documentation. Eide (2000, Tables 1 and 2) documents 25 YMP DSNF-related FEPs derived using a master logic diagram (MLD) approach and an additional 15 DSNF FEPs derived using a comparison approach (CA) between DSNF and commercial spent nuclear fuel (CSNF). The origin of the 18 criticality FEPs from CRWMS M&O (1998, Section 3.1) is noted in specific entries in the database. These FEPs include in-situ criticality (ISC), near-field criticality (NFC), and far-field criticality (FFC).

A second round of reviews by subject matter experts was performed from May 1999 through January 2001 in association with the development of FEP AMRs (listed in Table 1). During the preparation of the FEP AMRs, subject matter experts reviewed the existing FEPs relevant to their subject area and, where necessary identified new or missing FEPs. This review and documentation process identified 13 additional FEPs as summarized in Table 5.

Table 5. Origin of the 13 FEPs Identified in FEP AMRs

FEP AMR Subject Area and ID		Number of FEPs	Reference
WF Misc	ANL-WIS-MD-000009	4	CRWMS M&O 2001h
WF Clad	ANL-WIS-MD-000008	2	CRWMS M&O 2000a
WF Col	ANL-WIS-MD-000012	4	CRWMS M&O 2001j
EBS	ANL-WIS-PA-000002	3	CRWMS M&O 2001a

For FEPs related to EBS degradation, flow, and transport, a systematic top-down study (CRWMS M&O 2000b) was performed to identify any potential FEPs not on the list of FEPs distributed to the EBS FEP AMR (CRWMS M&O 2001a). The results of the top-down study confirmed the existing EBS-related FEPs and identified the two of the four new EBS FEPs noted in Table 5.

2.4 EXTERNAL REVIEW OF THE YMP FEP LIST

An interim version of the YMP FEP list was provided to the NRC in association with the NRC/DOE Appendix 7 Meeting on the FEPs Database held September 8, 1999. A subsequent NRC audit that focused on the NFE FEPs in this interim version of the YMP FEP list identified one potential FEP unrelated to any existing FEPs (Pickett and Leslie 1999, Section 3.3.1, Table 3-3). The audit also identified three potential FEPs that were possibly related to existing FEPs. Two of these FEPs were subsequently determined to be redundant to or subsumed in existing FEPs. The other two FEPs, noted in Table 6, were added to the YMP FEP list.

In addition, a series of NRC Key Technical Issue (KTI) Issue Resolution Meetings were held between August 2000 and January 2001, to discuss the status of KTIs as outlined in NRC IRSRs. Two new UZ FEPs were identified during the Unsaturated and Saturated Flow Under Isothermal Conditions (USFIC) KTI Meeting, held August 16-17, 2000. One new Bio and two new SZ FEPs were identified during the Igneous Activity (IA) KTI Meeting, held August 29-31, 2000. One new FEP (Faulting Exhuming Waste Packages) was also added based on discussion in the Structural Deformation and Seismicity (SDS) IRSR (NRC 1999, Section 3.3.1.1). These new FEPs are all noted in Table 6.

Table 6. Origin of the 8 FEPs Identified in External Reviews

Review	Number of FEPs	Reference
NRC NFE Audit	2	Pickett and Leslie 1999, Section 3.3.1
USFIC KTI Meeting	2	CRWMS M&O 2001e
IA KTI Meeting	2	CRWMS M&O 2001c
	1	CRWMS M&O 2001b
SDS IRSR	1	NRC 1999, Section 3.3.1.1

2.5 FUTURE DEVELOPMENT OF THE YMP FEP LIST

While the FEPs catalogued in the YMP FEP Database REV 00 are considered to be reasonably comprehensive (see Section 6.1.1 for further discussion), the YMP FEP list is open and may continue to expand if additional FEPs are identified, either within the CRWMS M&O and DOE or from external sources. New FEPs, if identified, will be incorporated into subsequent revisions of the database.

REV 01 of the database is planned to be completed to support TSPA-SR REV 01, conditional on the completion of appropriate revisions of the FEP AMRs where necessary. In addition, this report is planned to be updated to REV 01 to describe the changes. The YMP FEP list in REV 01 of the database may be updated through the following activities:

- A systematic review of NRC IRSR Key Technical Issues and Subissues is planned to identify any new FEPs.
- A review of Version 1.2 of the NEA database to identify any new FEPs.
- Resolution of any outstanding NRC NFE audit issues identified in Pickett and Leslie (1999).
- Resolution of any outstanding issues identified in the TSPAI IRSR (NRC 2000, Section 5.2).

INTENTIONALLY LEFT BLANK

3. YMP FEP CLASSIFICATIONS

3.1 DATABASE STRUCTURE

Many FEP classification schemes are possible, and there is no inherently correct way to order FEPs. The structure of the YMP FEP Database REV 00 ICN 01 (Appendix B) follows the NEA classification scheme (SAM 1997, Section 3), in which FEPs are organized under a hierarchical structure of layers, categories, and headings. The NEA structure comprises a comprehensive group of subject areas potentially relevant to radioactive waste disposal that was developed to systematically classify the FEPs from seven different international programs (Section 2.1). The NEA classification scheme was selected because it maintains consistency between NEA and YMP databases, which facilitates reviewing for completeness.

The structure of the NEA FEP Database Version 1.0 is defined by 4 layers, 12 categories, and 134 headings. The search of YMP literature for FEPs by Barr (1999) identified an additional heading relevant to YMP (the Nuclear Criticality heading in the Geologic Environment category) that was not in the NEA database. Also, for consistency with other layers, a category (Assessment Issues and Assumptions) was added to the Assessment Basis layer. Therefore, the YMP FEP Database REV 00 ICN 01 has 4 layers, 13 categories, and 135 headings. The hierarchical relationship between these layers, categories, and headings is shown in Table 7.

Table 7. Hierarchical Structure of the YMP FEP Database REV 00 ICN 01

Layers	Categories	Headings (*)
0. Assessment Basis	0.1 Assessment Issues and Assumptions	0.1.01 Impacts of concern 0.1.02 Timescales 0.1.03 Spatial domain 0.1.04 Repository assumptions 0.1.05 Future human action assumptions 0.1.06 Future human behavior assumptions 0.1.07 Dose response assumptions 0.1.08 Aims of the assessment 0.1.09 Regulatory requirements and exclusions 0.1.10 Model and data issues
1. External Factors	1.1 Repository Issues	1.1.01 Site investigation 1.1.02 Excavation/construction 1.1.03 Emplacement of wastes 1.1.04 Closure and sealing 1.1.05 Records and markers 1.1.06 Waste allocation 1.1.07 Design 1.1.08 Quality control 1.1.09 Schedule and planning 1.1.10 Administrative control of site 1.1.11 Monitoring 1.1.12 Accidents and unplanned events 1.1.13 Retrievability

Table 7. Hierarchical Structure of the YMP FEP Database REV 00 ICN 01 (cont.)

Layers	Categories	Headings (*)
1. External Factors (cont.)	1.2 Geologic Processes and Effects	1.2.01 Tectonic movements 1.2.02 Deformation 1.2.03 Seismicity 1.2.04 Volcanic activity 1.2.05 Metamorphism 1.2.06 Hydrothermal activity 1.2.07 Erosion and sedimentation 1.2.08 Diagenesis 1.2.09 Salt diapirism and dissolution 1.2.10 Hydrologic response to geologic changes
	1.3 Climatic Processes and Effects	1.3.01 Climate change, global 1.3.02 Climate change, regional 1.3.03 Sea level changes 1.3.04 Periglacial effects 1.3.05 Glacial and ice sheet effects 1.3.06 Warm climate effects 1.3.07 Hydrologic response to climate change 1.3.08 Ecological response to climate change 1.3.09 Human response to climate change
	1.4 Future Human Actions (Active)	1.4.01 Human influences on climate 1.4.02 Inadvertent/deliberate human actions 1.4.03 Un-intrusive site investigation 1.4.04 Drilling activities 1.4.05 Mining and other underground activities 1.4.06 Surface environment 1.4.07 Water management (wells, reservoirs) 1.4.08 Social developments 1.4.09 Technological developments 1.4.10 Remedial actions 1.4.11 Explosions and crashes
	1.5 Other	1.5.01 Meteorite impact 1.5.02 Species evolution 1.5.03 Miscellaneous (earth tides)
2. Disposal System Domain: Environmental Factors	2.1 Wastes and Engineered Features	2.1.01 Inventory 2.1.02 Waste form 2.1.03 Waste container 2.1.04 Backfill 2.1.05 Seals, cavern/tunnel/shaft 2.1.06 Other features (drip shield, invert) 2.1.07 Mechanical processes and conditions 2.1.08 Hydrogeologic processes and conditions 2.1.09 Geochemical processes and conditions 2.1.10 Biological processes and conditions 2.1.11 Thermal processes and conditions 2.1.12 Gas sources and effects 2.1.13 Radiation effects 2.1.14 Nuclear criticality

Table 7. Hierarchical Structure of the YMP FEP Database REV 00 ICN 01 (cont.)

Layers	Categories	Headings (*)
2. Disposal System Domain: Environmental Factors (cont.)	2.2 Geologic Environment	2.2.01 Excavation disturbed zone 2.2.02 Host rock 2.2.03 Geologic units, other 2.2.04 Discontinuities, large scale 2.2.05 Contaminant transport pathways 2.2.06 Mechanical processes and conditions 2.2.07 Hydrogeologic processes and conditions 2.2.08 Geochemical processes and conditions 2.2.09 Biological processes and conditions 2.2.10 Thermal processes and conditions 2.2.11 Gas sources and effects 2.2.12 Undetected features 2.2.13 Geological resources 2.2.14 Nuclear criticality
	2.3 Surface Environment	2.3.01 Topography 2.3.02 Soil 2.3.03 Aquifers / water-bearing features, near surface 2.3.04 Lakes, rivers, streams, springs 2.3.05 Coastal features 2.3.06 Marine features 2.3.07 Atmosphere 2.3.08 Vegetation 2.3.09 Animal populations 2.3.10 Meteorology 2.3.11 Hydrologic regime and water balance 2.3.12 Erosion and deposition 2.3.13 Ecological / biological / microbial systems
	2.4 Human Behavior	2.4.01 Human characteristics 2.4.02 Adults, children, infants 2.4.03 Diet and fluid intake 2.4.04 Habits, non-diet-related 2.4.05 Community characteristics 2.4.06 Food and water processing and preparation 2.4.07 Dwellings 2.4.08 Wild / natural land and water use 2.4.09 Rural / agricultural land and water use 2.4.10 Urban / industrial land and water use 2.4.11 Leisure and other uses of environment
3. Disposal System Domain: Radionuclide / Contaminant Factors	3.1 Contaminant Characteristics	3.1.01 Radioactive decay and ingrowth 3.1.02 Chemical/organic toxin stability 3.1.03 Inorganics 3.1.04 Volatiles 3.1.05 Organics 3.1.06 Noble Gases

Table 7. Hierarchical Structure of the YMP FEP Database REV 00 ICN 01 (cont.)

Layers	Categories	Headings (*)
3. Disposal System Domain: Radionuclide / Contaminant Factors (cont.)	3.2 Contaminant Release / Migration Factors	3.2.01 Dissolution, precipitation, crystalization 3.2.02 Speciation and solubility 3.2.03 Sorption / desorption processes 3.2.04 Colloids 3.2.05 Chemical/complexing agents, effect on transport 3.2.06 Microbiological / plant-mediated processes 3.2.07 Water-mediated transport 3.2.08 Solid-mediated transport 3.2.09 Gas-mediated transport 3.2.10 Atmospheric transport 3.2.11 Animal, plant, microbe mediated transport 3.2.12 Human-action-mediated transport 3.2.13 Foodchains, uptake of contaminants in
	3.3 Exposure Factors	3.3.01 Drinking water, food, drugs, concentrations in 3.3.02 Environmental media, concentrations in 3.3.03 Non-food products, concentrations in 3.3.04 Exposure modes 3.3.05 Dosimetry 3.3.06 Radiological toxicity / effects 3.3.07 Non-radiological toxicity / effects 3.3.08 Radon exposure

* some heading descriptions are paraphrased

Each of the 1656 FEPs in the YMP FEP list identified in Section 2 of this report was assigned (mapped) to a single heading in the YMP FEP Database. For the 1261 FEPs adopted from other international programs (Table 2), preliminary mappings were based on the relationships identified in the NEA database, although some adjustments were made to reflect YMP-specific conditions. The task of finding unique mappings was complicated by the fact that many FEPs in the NEA database are mapped to multiple headings. In cases where more than one heading was identified, the most relevant one for YMP was selected and cross-references were made to the others. This approach eliminated duplicative entries in the YMP FEP Database. For the 395 YMP-specific FEPs (Tables 3 through 6), which are not included in the NEA database, preliminary mappings were made to the most relevant heading. The preliminary mappings were reviewed during the December 1998 to April 1999 workshops (Table 4) and during preparation of the FEP AMRs (Table 1) and some changes in mapping were made as defined by subject matter experts.

Each of the 1656 FEPs in the YMP FEP list is an individual entry (record) in the YMP FEP Database as are the 152 layer, category, and heading entries that define the YMP FEP classifications. Therefore, the YMP FEP Database REV 00 ICN 01 (Appendix B) contains a total of 1808 individual entries. The mapping of FEP entries to the heading entries resulted in a database where all related entries were grouped together under the same classification heading (with overarching categories and levels). Links between database entries and specific FEP AMR / PMR subject areas (see Section 3.4) allow for additional groupings to be examined. A further categorization of the entries, to better facilitate systematic screening, is described in Section 3.2.

3.2 PRIMARY AND SECONDARY FEPS

There is no uniquely correct level of detail at which to define and/or aggregate FEPs. In the case where FEPs are too narrowly defined, it is infeasible to develop specific screening decisions for each FEP. Instead, it becomes more efficient to develop more broadly based screening decisions that apply to multiple, related FEPs. In the case where FEPs are too coarsely defined, it becomes difficult to isolate important subissues and, consequently, some important subissues may get excluded while other unimportant issues may get included. For efficiency, FEPs need to be aggregated at the coarsest level at which technically sound screening decisions can be made, while still maintaining adequate detail for the purposes of the analysis.

The all-inclusive bottom-up approach used to develop the YMP FEP list resulted in considerable redundancy in the FEP list, because the same FEPs were frequently identified by multiple sources. This was especially true of the international FEPs, where each of the seven programs would often identify the same FEP (e.g., meteorite impact). It was also true of the YMP-specific FEPs (and some of the more general international FEPs), where variations of the same FEP would be identified in various literature or reviews.

To eliminate the redundancy and to create a more efficient aggregation of FEPs to carry forward into the screening process (Section 4), each of the 1808 entries catalogued in the YMP FEP Database REV 00 ICN 01 was further identified as either a primary, secondary, or classification (layer, category, or heading) entry. Assignments to each of the three types of entries were based on the follow criteria:

Primary FEP Entry - Database entries that encompass a single process or event, or a few closely related or coupled processes or events that can be addressed by a specific screening discussion. Each primary FEP is addressed by a YMP-specific screening discussion taken from one or more FEP AMRs. A primary FEP may also include one or more related secondary FEPs that are covered by the same screening discussion.

Secondary FEP Entry - Database entries that are (1) redundant to another FEP (e.g., several NEA contributors identified the same FEP), (2) specific to another program (and not relevant to YMP), or (3) better captured or subsumed in a more broadly-defined primary FEP. Each secondary FEP is mapped to a primary FEP and must be completely addressed by the screening discussion of that primary FEP.

Classification (Layer, Category, Heading) Entry - Database entries that represent the hierarchical levels of classification within the database (see Table 7). Classification entries are neither primary FEPs nor secondary FEPs. They are defined too broadly to be addressed by a single screening discussion (as with a primary FEP) and cannot be encompassed by an overlying FEP (as with a secondary FEP). Rather, they classify one or more underlying, related, primary FEPs and do not require screening discussions.

Based on the preliminary mapping of the FEP entries to the heading entries (described in Section 3.1), a preliminary attempt was made to identify primary, secondary, and classification entries. The following steps were followed:

1. The 4 layer, 13 category, and 135 heading entries were initially defined as classification entries (as described in step 4 below, some heading entries were subsequently re-classified as primary FEPs).
2. The FEP entries mapped under each heading were informally separated into groups of related FEPs (e.g., under 2.1.03 Waste Container were such groupings as corrosion, mechanical damage, and early failures).
3. Each of the informal groupings of related FEPs from step 2 was further evaluated to identify FEPs that would likely require separate screening discussions. These independent FEPs were identified as primary FEPs (with no associated secondary FEPs).
4. In some cases, the informal groupings of FEPs under a specific heading entry were closely enough related that they could all be addressed by a screening discussion at the overlying heading level. In these cases, the heading entry (previously defined as a classification entry in step 1) was designated as a primary FEP. The underlying FEPs were designated as secondary FEPs to the heading level primary FEP.
5. Each of the remaining informal groupings of related FEPs from step 2 (that were not mapped as independent in step 3 or heading level in step 4) was further evaluated to better identify (a) multiple FEPs covering related or coupled processes or events that could likely be addressed by a single screening discussion, or (b) redundant FEPs. The resulting groups of FEPs were each selected to be represented by a primary FEP.
6. Each of the primary FEP groups identified from step 5 was examined to select a specific primary FEP. The primary FEP was chosen from the group of related or redundant FEPs as the FEP that best represented and was most inclusive of the group of FEPs as a whole. The other FEPs in the group were designated as secondary FEPs to the selected primary FEP.
7. For each of the primary FEPs (selected in steps 3, 4, and 6), a YMP primary FEP description was prepared. This description was based on the FEP description provided by the originator (e.g., the NEA database or YMP literature). The originator description was (a) edited to ensure that it was specific to YMP, and (b) expanded to ensure that all aspects of the related secondary FEPs were also addressed.

Because any categorization of FEPs is subjective, the preliminary identification of primary, secondary, and classification entries was reviewed by subject matter experts. During the December 1998 to April 1999 workshops (Table 4) some primary and secondary categorizations were revised and some of the FEPs were remapped to different headings. During preparation of the FEP AMRs (Table 1), additional changes to primary and secondary FEP mappings and to the YMP primary FEP descriptions were identified. The FEP AMRs also confirmed that the remaining mappings were appropriate and that the YMP primary FEP descriptions did encompass all aspects of the related secondary FEPs.

After all the reviews and confirmations, the YMP FEP Database REV 00 ICN 01 (Appendix B) contains 112 classification entries (152 less 40 heading entries that are also primary FEPs), 328 primary FEP entries (including the 40 headings) and 1368 secondary FEP entries.

The objective of the categorization into primary, secondary, and classification entries was to identify a subset of FEP entries, the primary FEPs, which capture all of the issues relevant to the postclosure performance of the potential Yucca Mountain repository and that can be addressed at an appropriate level of screening. As a result of the categorization described in this section, it was only necessary to develop screening decisions and supporting documentation (as described in Section 4) for the 328 primary FEPs, not for all 1808 YMP FEP list entries. All secondary FEPs were screened at the overlying primary FEP level.

3.3 ORGANIZATION AND NUMBERING OF DATABASE ENTRIES

The organization of the FEP entries within the YMP FEP Database REV 00 to follow the NEA hierarchical structure is controlled by the YMP FEP database number associated with each FEP entry. This number has the form x.x.xx.xx.xx and defines classification (layer, category, heading), primary, and secondary entries as follows:

x.0.00.00.00 Layer

x.x.00.00.00 Category

x.x.xx.00.00 Heading (some of these are also Primary FEPs)

x.x.xx.xx.00 Primary FEP (where the first x.x.xx is the overlying Heading)

x.x.xx.xx.xx Secondary FEP (where the first x.x.xx.xx is the overlying primary FEP)

With this numbering scheme, the YMP FEP database number always identifies to which heading a primary FEP is mapped and to which primary FEP a secondary FEP is associated.

The Microsoft Access electronic version of REV 00 ICN 01 (see Section 5.5) has an option to display the database with a directory tree indicating the YMP FEP database numbers and FEP names. The directory tree can be expanded or contracted with a mouse click, in similar fashion to a Microsoft Windows Explorer directory view. This directory tree functionality can be used to easily view the numbering scheme, see where in the database hierarchy a particular FEP is assigned, and identify related FEPs.

The Microsoft Access version also has the capability to perform keyword searches from a pull-down menu. This functionality allows FEPs with common feature, event, or process keywords to be identified. The lists of keywords are not yet implemented. However, for subsequent revisions, keywords will be assigned to all primary FEPs.

3.4 DATABASE FIELDS

For each of the 1808 entries in REV 00 ICN 01 of the database, there are 22 data/text fields. Each of these fields is described below. Fields which contain input or confirmation from the FEP AMRs are noted with a <u>double underline</u>.

YMP FEP Database Number: Numeric identifier that places the FEP in the proper location within the database structure. The numbering scheme follows a hierarchical structure classifying FEPs into layers (x...), categories (x.x...), headings (x.x.xx...), primary FEPs (x.x.xx.xx...), and secondary FEPs (x.x.xx.xx.xx).

FEP Name: Short, descriptive title of the FEP.

FEP Class: Identification of primary, secondary, and classification (layer, category, heading) entries. Primary FEPs are those FEPs for which the YMP has developed and documented screening discussions. Secondary FEPs are mapped to primary FEPs either because they are redundant with the associated primary FEP or because they represent a subcase of the primary FEP that is more effectively addressed at a higher level. Secondary FEPs are retained in the database for completeness, but users of the database are referred to the related Primary FEPs for the screening discussions.

Related Primary FEP(s): Identification of entries containing related information. For primary FEPs, other related primary FEPs (if any) are listed. For secondary FEPs and classification entries this field is blank. Related secondary and classification FEPs can instead be determined through the hierarchical numbering scheme.

Source Identifier: Alphanumeric identifier that provides traceability to the originator (e.g., NEA contributing program, YMP workshop, FEP AMR, etc.) as shown in Table 8. Note that the Source Identifier is not related to the NEA structure or YMP FEP Database Number.

NEA Category: Alphanumeric identifier used for the preliminary mapping of the FEPs relative to the NEA database headings. This field is based on preliminary mapping and has been superceded by the YMP FEP Database Number field. It is retained only for traceability to earlier versions of the database. Note that for new FEPs that were identified during and subsequent to the December 1998 to April 1999 workshops, the Source Identifier is repeated in the NEA Category field.

YMP Primary FEP Description: Description of each FEP and its potential relevance to YMP, typically edited from the Originator FEP Description. Where secondary FEPs are associated with a primary FEP, the description also includes all of the features, events, and processes described by the secondary FEPs. For shared FEPs (see Section 4.2), descriptions from each input AMR are listed and are not integrated.

Originator FEP Description: Verbatim text of the FEP description from originator documentation. The originator is noted in parentheses where possible.

Screening Decision and Regulatory Basis: A statement of whether the FEP is included in the quantitative TSPA models or excluded from the TSPA on specific criteria provided by the regulations.

Screening Argument: A summary discussion of the technical basis for the Screening Decision, with citations to appropriate AMRs (for excluded FEPs, this is the key text).

TSPA Disposition: A summary discussion of the treatment of the FEP in the TSPA, with citations and cross-references to the appropriate AMRs (for included FEPs, this is the key text).

Treatment of Secondary FEP(s): For primary FEPs, a list of the underlying secondary FEPs is provided with a short description of the relationship of each secondary FEP to the primary FEP and a summary of how the secondary FEP is addressed in the Screening Argument or TSPA Disposition.

Input AMR: Identifies the FEP AMR where the qualified screening discussion is documented. Verbatim text for several fields including the Screening Decision and Regulatory Basis, Screening Argument, TSPA Disposition, Supplemental Discussion, and Treatment of Secondary FEPs was taken from the input AMR. The input AMR identifier also indicates the subject area in which the FEP is grouped. For shared FEPs (see Section 4.2), all of the input AMRs are listed. The input AMRs can be accessed directly from the database using hyperlink buttons.

IRSR: Identifies NRC IRSR subissues related to the FEP.

Supplemental Discussion: Provides additional information supporting the Screening Decision, beyond what is summarized in the Screening Argument and TSPA Disposition fields.

Cited References: Identifies the FEP AMR references cited in the Screening Argument, TSPA Disposition, and Supplemental Discussion summaries. The FEP AMR references are accessed through hyperlinks to the reference section of the input AMRs.

Modified by: Name of last person to modify the FEP record.

Modified on: Date and time of last modification to the FEP record.

F Keyword: Identifier feature keyword from a specified list that is used for keyword searches. For REV 00 ICN 01 this field is blank.

E Keyword: Identifier event keyword from a specified list that is used for keyword searches. For REV 00 ICN 01 this field is blank.

P Keyword: Identifier process keyword from a specified list that is used for keyword searches. For REV 00 ICN 01 this field is blank.

Notes: Miscellaneous notes and comments related to the FEP.

Table 8. Abbreviations Used in Source Identifier Field

Source (see Tables 2 through 6)	Source Identifier Format
AECL	Ax.xxx
NEA	Nx.x.xx
SKI/SKB	Jx.x.xx
SKI	Sxxx
HMIP	HMIPx.x.x
NAGRA	Kx.xx
DOE-WIPP	Wx.xxx
YMP Site Characterization Plan (YSCP)	YSCPxx
Other YMP Documents	YMxx
UZ Workshop	UZ/xxxx
DSNF Workshop	CA-x, MLD-x
WF Workshop	WF/xxxx
DE Workshop	DE/xxxx, ISC-x, NFC-x, FFC-x
SZ/Bio Workshop	SZ/xxxx, BIO/xxxx
TH Workshop	TH/xxxx
IDGE Workshop	ID/xxxx
WP Workshop	WP/xxxx
NEA Layer, Category, Heading	NEA xxxxxxxx
Other Layer, Category, Heading	Non-NEA xxxxxxxx
WF Miscellaneous FEP AMR	WFMisc AMR-x
WF Cladding FEP AMR	WFClad AMR-x
WF Colloid FEP AMR	WFCol AMR-x
EBS FEP AMR	EBS AMR-x
NRC NFE Audit	NRC NFE-x
USFIC KTI Meeting	NRC USFIC-x
Igneous Activity (IA) KTI Meeting	NRC IA-x
NRC SDS IRSR	NRC SDS-x

3.5 FUTURE DEVELOPMENT OF THE YMP FEP CLASSIFICATIONS

REV 01 of the database is planned to be completed to support TSPA-SR REV 01, conditional on the completion of appropriate revisions of the FEP AMRs where necessary. In addition, this report is planned to be updated to REV 01 to describe the changes. The classifications, categorizations, and the identification of relationships between FEPs in REV 01 of the database may be updated through the following activities:

- Addition of separate keyword lists for features, events, and processes to enable the keyword search capability that is described in Section 3.3.
-

- Identification of mapping between FEPs and entries in a proposed database of NRC IRSR Key Technical Issues and subissues.
- Identification of mapping between FEPs and process model factors from the Repository Safety Strategy (RSS).
- Further identification of FEP relationships, if necessary (e.g., development of an interaction matrix).

INTENTIONALLY LEFT BLANK

4. YMP FEP SCREENING DECISIONS AND SUPPORTING DOCUMENTATION

4.1 SCREENING CRITERIA

Each primary FEP (and, by association, each secondary FEP) was screened for inclusion or exclusion in the TSPA on the basis of three criteria, developed from DOE's Interim Guidance (Dyer 1999). The three criteria are as follows:

Regulatory – DOE's Interim Guidance (Dyer 1999, Subpart E) provides regulatory guidance regarding certain assumptions about the TSPA. Some FEPs may be specifically exempted from consideration in TSPA because they are not in accordance with this regulatory guidance or are not applicable by regulation. FEPs which are inconsistent with these regulatory assumptions may be excluded (screened out) from the TSPA by regulation. For example, any FEPs which invoke human intrusion scenarios or critical group characteristics that are inconsistent with what is specified in the regulations are screened out by regulation.

Probability - The probability criterion is stated in DOE's Interim Guidance (Dyer 1999, Section 114):

> (d) Consider only events that have at least one chance in 10,000 of occurring over 10,000 years.

FEPs with a lower probability of occurrence may be excluded (screened out) from the TSPA on the basis of low probability.

Consequence - The consequence criteria are stated in DOE's Interim Guidance (Dyer 1999, Section 114):

> (e) Provide the technical basis for either inclusion or exclusion of specific features, events and processes of the geologic setting in the performance assessment. 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.
>
> (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.

FEPs whose exclusion would not significantly change the expected annual dose may be excluded (screened out) from the TSPA on the basis of low consequence.

4.2 SCREENING GUIDELINES AND IMPLEMENTATION

Because DOE's Interim Guidance (Dyer 1999, Section 114) allows exclusion of FEPs on the basis of either low probability or low consequence, a FEP need not be shown to be both of low probability and low consequence to be excluded. Therefore, the order in which the criteria are applied is not essential. In some cases, a component of the FEP was included while another component of the FEP was excluded. In practice, regulatory criteria are examined first, then, at the discretion of the analyst, either probability or consequence criteria are examined next.

As noted in Section 1, the FEP screening was performed by subject matter experts and documented in FEP AMRs (listed in Table 1). Specific screening data from the FEP AMRs was then imported into the YMP FEP Database REV 00 ICN 01, in accordance with the technical work plan (CRWMS M&O 2001i). The screening data is catalogued in the database. The verification of the technical accuracy and completeness of the screening data is the responsibility of the FEP AMRs. Hyperlinks from the database to the FEP AMRs are enabled for each FEP.

The specific database fields containing screening data from the FEP AMRs were identified in Section 3.4. To satisfy the screening criteria of DOE's Interim Guidance (Dyer 1999, Section 114) and to satisfy the TSPAI IRSR subissues pertaining to FEPs and scenario analysis (NRC 2000, Section 4.2), guidelines have been established for the content of four of these fields: YMP Primary FEP Description, Screening Decision and Regulatory Basis, Screening Argument, and TSPA Disposition. Because the technical defensibility of the content of these fields is the responsibility of the FEP AMRs, these guidelines apply to the FEP AMRs. Key aspects of the guidelines are summarized below:

YMP Primary FEP Description – It must be relevant to YMP and must include all of the related features, events, and processes identified in associated secondary FEPs.

Screening Decision and Regulatory Basis – It must state whether the FEP is included or excluded from the TSPA.

For excluded FEPs, the exclusion criteria (regulation, low probability, low consequence) must be explicitly identified.

For partially included or partially excluded FEPs, the various components that are included and excluded must be identified. As an example, FEP 1.2.02.01.000, Fractures, is identified as follows: Included (existing fracture characteristics); Excluded - Low Consequence to Dose (changes of fracture characteristics).

Screening Argument - For excluded FEPs this is the main screening discussion. A summary of the technical basis for exclusion must be presented, and the summary must address all secondary FEP issues.

Low probability exclusions must include an explicit comparison of the probability of occurrence to the regulatory criteria ($<10^{-4}$ in 10,000 years). The probability must be quantified where possible, although non-quantitative low-probability arguments are acceptable for "not credible" FEPs.

Low consequence exclusions must include an explicit statement that there is "no significant change in the expected annual dose". The change in expected annual dose must be quantified where possible, and the interpretation of "significant change" must be described (it may be different for each FEP). It is acceptable to quantify the change in an intermediate performance measure (e.g. radionuclide mass release to the saturated zone). However, in that case, the qualitative link to change in expected annual dose must be explicitly stated.

Regulatory exclusions must identify a specific regulation and clearly state the rationale for the exclusion.

TSPA Disposition - For included FEPs this is the main screening discussion. A summary discussion of the treatment of the FEP in the TSPA must be presented. A statement of the scenario class, model and/or abstraction is desirable.

In some cases, a primary FEP may affect multiple facets of the project, may be relevant to more than one FEP AMR subject area, or may not fit neatly within the FEP AMR structure. In these cases, rather than create multiple separate FEPs, the FEP was assigned to more than one FEP AMR. These shared FEPs then had separate screening discussions prepared in the separate FEP AMRs. While informal meetings were held to resolve any contradictory screening discussions for shared FEPs, the multiple screening discussions input to the database were not integrated. As a result, shared FEPs in REV 00 may contain duplicative screening information. Similarly, some FEP AMRs modified the YMP Primary FEP Descriptions to ensure that all implications of the secondary FEPs were subsumed in the YMP Primary FEP Descriptions. Where these modified FEPs were shared FEPs, multiple YMP Primary FEP Descriptions were input to the database but not integrated.

4.3 FUTURE DEVELOPMENT OF THE YMP FEP SCREENING DATA

REV 01 of the database is planned to be completed to support TSPA-SR REV 01, conditional on the completion of appropriate revisions of the FEP AMRs where necessary. In addition, this report is planned to be updated to REV 01 to describe the changes. The FEP screening data in the database may be updated through the following activities:

- Addition of screening decisions based on a lower thermal load design (CRWMS M&O 2000f, Section 4.6.2). The screening discussions in REV 00 of the database are based on a reference repository design as described in the TSPA-SR (CRWMS M&O 2000f, Section 1.7). The FEP AMRs will be revised to add screening discussions for the lower thermal load design, where necessary. This information will then be transferred to the database.
- Integration of screening information and YMP primary descriptions for shared FEPs (see Section 4.2).
- Identification of the scenario class (Nominal, Disruptive, or Human Intrusion) in the Screening Decision field for included FEPs.
- Review of screening discussions, where necessary, to ensure adherence to the content guidelines outlined in Section 4.2. Any revisions should be made in the FEP AMRs rather than in the database directly.

INTENTIONALLY LEFT BLANK

5. DEVELOPMENT HISTORY OF YMP FEP DATABASE

5.1 REV 00A

To initiate the FEP screening process for TSPA-SR, a YMP FEP list was distributed electronically on July 1, 1999 to representatives of the FEP AMRs and the associated PMRs listed in Table 1. This preliminary YMP FEP list was catalogued in a preliminary version of the YMP FEP Database identified as REV 00A. The YMP FEP list in REV 00A contained 1786 entries, categorized as 310 primary and 1476 secondary FEP entries (in REV 00A non-primary classification entries were not distinguished from secondary FEP entries). REV 00A contained the preliminary YMP Primary FEP Descriptions and draft placeholder text for Screening Decisions, Screening Arguments, and TSPA Dispositions. The placeholder text consisted of preliminary brainstorming information compiled by non-subject matter experts. REV 00A also contained a preliminary mapping of primary and secondary FEPs and preliminary FEP AMR and PMR assignments.

Guidance to the FEP AMR subject matter experts (see Section 4.2) requested reviews, edits, and/or replacements to the placeholder text for all of their assigned primary FEPs. The guidance also requested a review to confirm (or suggest changes) that the YMP Primary FEP Descriptions included all relevant issues from associated secondary FEPs and that the primary / secondary mappings and FEP AMR assignments were appropriate.

REV 00A, while containing uncontrolled information, marked a transition from the developmental to the operational stage in YMP FEP work. Previous versions of the database had been created for testing, informal internal distribution, and distribution at the December 1998 to April 1999 technical workshops (see Table 4). Information contained in these previous versions had been entered carefully and managed in accordance with standard good working practices, but no formal procedures had been applied that would allow (or require) the database to meet quality assurance (QA) standards for electronic information management.

The master copy of REV 00A was created in Claris FileMaker Pro Version 4.1. The distribution copies, which contain identical information, were in Microsoft Access 97 format.

5.2 REV 00B

The YMP FEP Database REV 00B (CRWMS M&O 1999c) was created from REV 00A for distribution to NRC personnel attending a DOE/NRC Appendix 7 Meeting on FEPs on September 8, 1999. REV 00B was created in Microsoft Access 97 format as a direct copy of the Microsoft Access version of REV 00A. REV 00B contained minor changes from REV 00A designed to ensure that the recipients (NRC and other personnel) were aware that they had a preliminary version of the FEP Database. Specific changes included adding text to the initial "splash" screen to identify the preliminary status of REV 00B and altering the font of the draft placeholder text to italics. There were no changes to the number, organization, or content of the FEP entries themselves. This preliminary version was used by the NRC as a basis for review comments documented in the TSPAI IRSR (NRC 2000, Section 5.2.2).

5.3 REV 00C

REV 00C (CRWMS M&O 1999b) was derived from, and is similar to, REV 00A and REV 00B. It contains the same 1786 entries (310 primary FEP entries and 1476 secondary FEP entries). REV 00C was the first revision with information controlled in accordance with a qualified procedure, YAP-SV.1Q, *Control of the Electronic Management of Data.* The data control process is outlined in CRWMS M&O 1999a. REV 00C was created in preparation for input of screening information developed in the FEP AMRs. Changes from REV 00A are described in detail in the documentation for REV 00C (CRWMS M&O 1999b). The major changes were:

1. Draft placeholder text (screening decision and supporting documentation) was deleted from the database.
2. Introductory text was added to the database as a separate FileMaker file.

The master copy of REV 00C was created in Claris FileMaker Pro Version 4.1. The FileMaker passwords are "ympfep99" for full function mode and "view" for read-only mode. The FileMaker version included two files: REV00c.fp3 (containing FEP information) and FEPIntro00c.fp3 (containing introductory text).

A distribution version of REV 00C was produced in Microsoft Access 97. The FEP information was transferred from the FileMaker file Rev00c.fp3 using an electronic data transfer procedure. The corresponding Microsoft Access file was FEPs00c.mdb. FEPs00c.mdb contains all the FEP entry information but the layout formatting and custom toolbar functionality, available in previous Microsoft Access 97 versions, was removed. Introductory text from FEPIntro00c.fp3 was copied to Microsoft Word 97 file FEPIntro00c.doc.

5.4 REV 00 ICN 00

REV 00 ICN 00 (CRWMS M&O 2000e) was developed to satisfy a Level 3 Deliverable Milestone to DOE . The FEP AMR subject matter experts reviewed each of their assigned primary FEP entries and the associated secondary FEP entries (distributed as REV 00A) and produced a screening decision and supporting documentation within their FEP AMR. The subject matter experts also reviewed and either confirmed or suggested changes to the YMP Primary FEP Descriptions, the primary / secondary mappings, and the FEP AMR assignments. REV 00 ICN 00 was initiated by transferring the qualified screening data from the FEP AMRs to REV 00C in accordance with the data transfer controls in CRWMS M&O (1999b). A complete list of changes from REV 00C to REV 00 ICN 00, including notes on the data transfer from the FEP AMRs to the database, is documented in Microsoft Word 97 file Changes_to_Rev00c.doc (CRWMS M&O 2000e, Appendix D). In addition to the input of screening data from the FEP AMRs, other major changes from REV 00C were:

1. Eleven (11) new primary FEPs were added based on FEP AMR reviews (Table 5) and the NRC NFE audit (Table 6).
2. Two (2) FEPs were elevated from secondary FEPs to primary FEPs based on FEP AMR reviews.
3. Layer, category, and heading entries were identified as classification entries rather than secondary FEPs.
4. Cross-references to the NEA category were replaced with cross-references to the YMP FEP database number.

5. Gaps in the numbering scheme, erroneously present in REV 00C, were eliminated.
6. A custom toolbar was added to Microsoft Access that provided enhanced features for searching, sorting, and editing the FEP entries, and for viewing a directory tree of the FEPs and their relationships.

REV 00 ICN 00 contained 1797 entries, categorized as 111 classification entries (151 less 40 heading entries that are also primary FEPs), 323 primary FEP entries (including the 40 headings) and 1363 secondary FEP entries.

The master copy of REV 00 ICN 00 was maintained in Claris FileMaker Pro Version 4.1. The FileMaker passwords are "ympfep99" for full function mode and "view" for read-only mode. The FileMaker version includes two files: Rev00.fp3 (containing FEP information) and FEPIntro00.fp3 (containing introductory text).

A distribution version was produced in Microsoft Access 97. The FEP information was transferred from the FileMaker file Rev00.fp3 using the data transfer procedure described in the CRWMS M&O (2000e, Appendix C). The corresponding MS Access file is FEPs00.mdb. FEPs00.mdb contains all the FEP information and also includes custom toolbars for editing, sorting, filtering, viewing the directory tree, and performing keyword searches. Introductory text from FEPIntro00.fp3 is contained in Microsoft Word 97 file FEPIntro00.doc.

REV 00 ICN 00 was submitted to the DOE as Level 3 Deliverable on June 30, 2000. In September 2000, DOE issued a Technical Direction letter stating that the FEPs Database REV 00 ICN 00 was "accepted with conditions" (Horton 2000).

5.5 REV 00 ICN 01

REV 00 ICN 01 was developed to address the conditions outlined in the DOE Technical Direction letter (Horton 2000). Specific conditions were addressed through:

- Qualification of the database routines (but not the data) in accordance with AP-SI.1Q, *Software Management*.
- Incorporation of changes and revisions to the FEP AMRs to consider the "no-backfill" design.
- Incorporation of changes and revisions to the FEP AMRs to include criticality and other identified missing FEPs.
- Incorporation of changes and revisions to the FEP AMRs to address regulatory and legal comments made on Rev. 00 of the FEP AMRs.

This report describes the development of REV 00 of the YMP FEP Database. It includes aspects of REV 00 ICN 00 and REV 00 ICN 01 (Appendix B). REV 00 ICN 01 was produced through enhancements to REV 00 ICN 00 (Section 5.4). During the changes and revisions to the FEP AMRs to address the conditions noted above, subject matter experts also were able to further review the FEP descriptions, the primary / secondary mappings, the screening decisions, and the supporting documentation within their FEP AMR. Specific enhancements for REV 00 ICN 01, resulting from the database qualification and from changes and revisions to the FEP AMRs, were:

1. Six (6) new primary FEPs were added based on FEP AMR reviews (Table 5) and NRC KTI Meetings (Table 6).
2. Four (4) new secondary FEPs were added based on FEP AMR reviews (Table 5) and NRC KTI Meetings and IRSR reviews (Table 6).
3. One (1) new classification entry was added (as described in Section 3.1).
4. One (1) primary FEP was changed to a secondary FEP (underlying one of the new primary FEPs) based on FEP AMR reviews.
5. One field, Treatment of Secondary FEP(s), was added to identify the specific relationship and screening of secondary FEPs relative to the primary FEPs.
6. Five fields which are no longer used were removed.
7. The functionality of the database within Microsoft Access was enhanced. The searching, sorting, editing, viewing, and printing capabilities were refined and hyperlinks to the screening documentation in the FEPs AMRs were added.

REV 00 ICN 01 contains 1808 entries, categorized as 112 classification entries (152 less 40 heading entries that are also primary FEPs), 328 primary FEP entries (including the 40 headings) and 1368 secondary FEP entries.

For REV 00 ICN 01, Claris FileMaker Pro Version 4.1 was no longer used. Both the master copy and distribution versions were produced in Microsoft Access 97. The FEP information was transferred directly from the FEP AMRs to the MS Access file, FEPs00_ICN01.mde. FEPs00_ICN01.mde contains all the FEP information and also includes custom toolbars for editing, sorting, filtering, viewing the directory tree, and performing keyword searches. FEP text containing tables, figures, and non-standard fonts (i.e., greek letters, symbols, italics, superscripts, and subscripts) did not transfer verbatim from the FEP AMRs to the database. Therefore, hyperlinks to the verbatim FEP text in the AMRs were provided in the database. In addition, introductory text is contained in Microsoft Word 97 file FEPIntro_ICN01.doc and a user guide is contained in Microsoft Word 97 file FEPUser00_ICN01.doc. Both of these documents can be accessed directly from the database.

All of the Microsoft Access and Microsoft Word files listed in this section are included on the compact disc attached to this report in Appendix B. Microsoft Access 97 (database manager), and Microsoft Word 97 (word processor) are both commercially available software. Microsoft Word is exempt from any special controls per AP-SI.1Q, *Software Management*. Microsoft Access database routines were qualified (CRWMS M&O 2001f, STN: 10418-00-00) under AP-SI.1Q, *Software Management*.

6. SUMMARY

The YMP FEP Database REV 00 ICN 01 (Appendix B) contains three types of information: a list of potentially relevant FEPs (the YMP FEP list); an organizational structure that categorizes the YMP FEP list into groups of related FEPs (the YMP FEP Classification); and screening decisions and supporting documentation.

The database structure is hierarchical, consisting of overarching classification entries (levels, categories, and headings), primary FEPs, and secondary FEPs. The primary FEPs collectively capture all of the issues relevant to the postclosure performance of the proposed Yucca Mountain repository. Each primary FEP requires a screening discussion identifying the technical basis for inclusion or exclusion of FEPs in the TSPA-SR analyses. Secondary FEPs are subsumed in or redundant to overlying primary FEPs and do not require screening discussions.

The YMP FEP Database REV 00 ICN 01 (Appendix B) contains 112 classification entries (152 less 40 heading entries that are also primary FEPs), 328 primary FEP entries (including the 40 headings) and 1368 secondary FEP entries, for a total of 1808 entries. For each database entry, there are 22 data/text fields available for classification, description, and/or screening information.

Screening discussions for each of the 328 primary FEPs were prepared by subject matter experts and documented in FEP AMRs. The screening discussions were then imported from the FEP AMRs into the YMP FEP database. Guidelines were established to ensure that the content of the screening data was sufficient to satisfy regulatory screening criteria. This document may be affected by technical product input information that requires confirmation. Any changes to the document that may occur as a result of completing the confirmation activities will be reflected in subsequent revisions. The status of the input information quality may be confirmed by review of the Document Input Reference System database.

6.1 DISCUSSION OF AREAS OF DEFICIENCY RELEVANT TO NRC ACCEPTANCE CRITERIA

The TSPAI IRSR (NRC 2000, Section 5.2.2) identified four areas of deficiency relevant to FEPs identification, classification, and screening. The following subsections discuss how each of these areas of deficiency are addressed by the YMP FEP Database REV 00 ICN 01.

6.1.1 Identification of Initial FEPs

These acceptance criteria address the comprehensiveness of the FEP list. Relevant areas of deficiency are: the lack of documentation of the approach to constructing the database; and the identification of missing FEPs.

This report provides documentation of the construction of the FEP list and the database. The YMP FEP list was initially developed from a comprehensive list of FEPs from other international radioactive waste disposal programs (Section 2.1) and was supplemented with additional YMP-specific FEPs from project literature, technical workshops, and reviews (Sections 2.2 through 2.4). These bottom-up compilations produced an extensive, wide-ranging set of FEPs with the potential to influence repository performance.

The comprehensiveness of the YMP FEP list derives in part from the NEA-based database structure. The NEA structure comprises a comprehensive group of subject areas (i.e., headings)

potentially relevant to radioactive waste disposal that was developed to systematically classify the FEPs from seven different international programs. Continuous iterative review (i.e., at workshops and in FEP AMRs) of all database subject areas assures a strong degree of comprehensiveness, and ensures that no subject area is overlooked. Further assurance of comprehensiveness arises from the results of the most recent iterative reviews (Table 5 and Table 6). Only 13 and 8 new FEPs, respectively, were identified, and these new FEPs were variants of existing FEPs rather than representing entirely new subject areas. The diminishing returns of these iterative reviews suggest that the REV 00 ICN 01 YMP FEP list is quite comprehensive and that missing FEPs are typically variants or combinations of existing FEPs.

6.1.2 Classification of FEPs

These acceptance criteria address the grouping and categorization of FEPs. The relevant area of deficiency is insufficient documentation and assurance that primary FEPs envelop all secondary FEPs.

The all-inclusive bottom-up approach used to develop the YMP FEP list resulted in considerable redundancy in the FEP list. To eliminate the redundancy and to create a more efficient aggregation of FEPs to carry forward into the screening process, each of the 1808 entries catalogued in the YMP FEP Database REV 00 ICN 01 was identified as either a primary, secondary, or classification (layer, category, or heading) entry. The process and criteria for assigning FEPs to one of these categories is described in Section 3.2. Because any categorization of FEPs is subjective, the preliminary identification of primary, secondary, and classification entries was reviewed and, where necessary, revised by subject matter experts.

This categorization resulted in a list of 328 primary FEPs that were carried forward for screening. Explicit screening of the secondary (and classification) FEPs was not required because the aspects of the secondary FEPs were encompassed by the primary FEPs. The relationships between secondary FEPs and their associated primary FEPs along with the justification for the secondary FEP screening are explicitly stated in the database field, Treatment of Secondary FEP(s).

6.1.3 Screening of Initial FEPs

These acceptance criteria address the screening of the FEPs. The relevant area of deficiency is the need for better technical bases for screening.

The regulatory criteria for screening FEPs on the basis of low probability, low consequence, or regulatory specification are summarized in Section 4.1. To satisfy these regulatory screening criteria and to satisfy the need for better technical bases for screening, guidelines were established for the content of the screening discussions in the FEP AMRs in Table 1. The FEP AMRs also underwent legal and technical review specifically aimed at strengthening the technical bases. In cases where the screening discussions input from the FEP AMRs are found to not fully satisfy the guidelines, revisions may be made to the FEP AMRs that will be reflected in subsequent revisions of the database.

6.1.4 Transparency and Traceability

These acceptance criteria address the transparency and traceability of data within the FEP database and with other project documents (AMRs, PMRs, etc.). Relevant areas of deficiency

are: insufficient documentation; and the lack of a protocol to ensure consistency among the various project documents when updates are made.

The origins of all YMP FEPs are described in Section 2 of this report and tracked in database field Source Identifier. The screening process by which FEPs were included or excluded from the TSPA is described in Section 4. The source document for screening information is reported in the database field Input AMR.

Relationships between relevant FEPs are identified in several ways. Related FEPs are inherently grouped together in accordance with the NEA-based hierarchical numbering scheme (Section 3.1). The tree directory functionality in the database allows database users to graphically view and identify these groupings. Related FEPs are also grouped according to subject area (using database fields YMP FEP Database Number and Input AMR). Finally, in future revisions to the database, related FEPs will be able to be identified using the keyword search pull-down menu.

INTENTIONALLY LEFT BLANK

7. REFERENCES

7.1 DOCUMENTS CITED

Andersson, J.; Carlsson, T.; Eng, T.; Kautsky, F.; Soderman, E.; and Wingefors, S. 1989. *The Joint SKI/SKB Scenario Development Project.* Andersson, J., ed. SKB Technical Report 89-35. Stockholm, Sweden: Swedish Nuclear Fuel and Waste Management Company. TIC: 208568.

Barr, G.E. 1999. "Origin of Yucca Mountain FEPs in the Database Prior to the Last Set of Workshops." Memorandum from G.E. Barr to P.N. Swift (SNL), May 20, 1999. ACC: MOL.19991214.0520.

Chapman, N.A.; Andersson, J.; Robinson, P.; Skagius, K.; Wene, C-O.; Wiborgh, M.; and Wingefors, S. 1995. *Systems Analysis, Scenario Construction and Consequence Analysis Definition for SITE-94.* SKI Report 95:26. Stockholm, Sweden: Swedish Nuclear Power Inspectorate. TIC: 238888.

CRWMS M&O 1998. *Disposal Criticality Analysis Methodology Topical Report.* B00000000-01717-5705-00095 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19980918.0005.

CRWMS M&O 1999a. Process Control Evaluation for Supplement V: "Develop and Control an Electronic Database of Features, Events, and Processes (FEPs) Potentially Relevant to the Proposed Yucca Mountain Repository". Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19991025.0080.

CRWMS M&O 1999b. *YMP FEP Database Rev. 00C.* Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19991214.0518; MOL.19991214.0519.

CRWMS M&O 1999c. *Yucca Mountain Project (YMP) Features, Events & Processes (FEP) Database Rev. 00B.* Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19991025.0082; MOL.19991025.0084.

CRWMS M&O 2000a. *Clad Degradation – FEPs Screening Arguments.* ANL-WIS-MD-000008 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001208.0061.

CRWMS M&O 2000b. *Engineered Barrier System Features, Events, and Processes, and Degradation Modes Analysis.* ANL-EBS-MD-000035 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000727.0092.

CRWMS M&O 2000c. *Features, Events, and Processes: Disruptive Events.* ANL-WIS-MD-000005 REV 00 ICN 1. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001218.0007.

CRWMS M&O 2000d. *Features, Events, and Processes: System-Level and Criticality.* ANL-WIS-MD-000019 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010108.0012.

CRWMS M&O 2000e. *The Development of Information Catalogued in REV00 of the YMP FEP Database.* TDR-WIS-MD-000003 REV 00. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20000705.0098.

CRWMS M&O 2000f. *Total System Performance Assessment for the Site Recommendation.* TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045.

CRWMS M&O 2001a. *Engineered Barrier System Features, Events, and Processes.* ANL-WIS-PA-000002 REV 01. Las Vegas, Nevada: CRWMS M&O. Submit to RPC URN-0655

CRWMS M&O 2001b. *Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEP).* ANL-MGR-MD-000011 REV 01. Las Vegas, Nevada: CRWMS M&O. Submit to RPC URN-0815

CRWMS M&O 2001c. *Features, Events, and Processes in SZ Flow and Transport.* ANL-NBS-MD-000002 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010214.0230.

CRWMS M&O 2001d. *Features, Events, and Processes in Thermal Hydrology and Coupled Processes.* ANL-NBS-MD-000004 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010220.0007.

CRWMS M&O 2001e. *Draft AMR REV01A, Features, Events, and Processes in UZ Flow and Transport (ANL-NBS-MD-000001).* Input Transmittal 00429.T. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010216.0008.

CRWMS M&O 2001f. *Software Routine: FEPs Database.* V00. STN: 10418-00-00.

CRWMS M&O 2001g. *FEPs Screening of Processes and Issues in Drip Shield and Waste Package Degradation.* ANL-EBS-PA-000002 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010216.0004.

CRWMS M&O 2001h. *Miscellaneous Waste-Form FEPs.* ANL-WIS-MD-000009 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010216.0006.

CRWMS M&O 2001i. *Technical Work Plan for: Total System Performance Assessment.* TWP-MGR-PA-000001 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010228.0156.

CRWMS M&O 2001j. *Waste Form Colloid-Associated Concentrations Limits: Abstraction and Summary.* ANL-WIS-MD-000012 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20010130.0002.

DOE (U.S. Department of Energy) 1988. *Site Characterization Plan Yucca Mountain Site, Nevada Research and Development Area, Nevada.* DOE/RW-0199. Nine volumes. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: HQO.19881201.0002.

DOE (U.S. Department of Energy) 1996. *Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant.* DOE/CAO-1996-2184. Twenty-one volumes. Carlsbad, New Mexico: U.S. Department of Energy, Carlsbad Area Office. TIC: 240511.

DOE (U.S. Department of Energy) 2000. *Quality Assurance Requirements and Description.* DOE/RW-0333P, Rev. 10. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20000427.0422.

Dyer, J.R. 1999. "Revised Interim Guidance Pending Issuance of New U.S. Nuclear Regulatory Commission (NRC) Regulations (Revision 01, July 22, 1999), for Yucca Mountain, Nevada." Letter from J.R. Dyer (DOE/YMSCO) to D.R. Wilkins (CRWMS M&O), September 3, 1999, OL&RC:SB-1714, with enclosure, "Interim Guidance Pending Issuance of New NRC Regulations for Yucca Mountain (Revision 01)." ACC: MOL.19990910.0079.

Eide, S.A. 2000. *Feature, Event, and Process Identification to Support Disposal of Department of Energy Spent Nuclear Fuel at the Yucca Mountain Repository.* NSNF/EP-3.05/001, Rev. 00. [Idaho Falls, Idaho: Idaho National Engineering and Environmental Laboratory]. ACC: MOL.20001012.0143.

Goodwin, B.W.; Stephens, M.E.; Davison, C.C.; Johnson, L.H.; and Zach, R. 1994. *Scenario Analysis for the Postclosure Assessment of the Canadian Concept for Nuclear Fuel Waste Disposal.* AECL-10969. Pinawa, Manitoba, Canada: AECL Research, Whiteshell Laboratories. TIC: 215123.

Horton, D.G. 2000. Technical Direction: Accepted with Conditions for Deliverable SL981M3, Features, Events, and Processes Database Revision 00, WBS 1.2.21.3, Work Package Identifier 33012132M2 Total System Performance Assessment Model Development, Contract # DE-AC08-91RW00134, YDAR 25939; TDL No. 00-0015." Letter from D.G. Horton (DOE/YMSCO) to G.E. Dials (CRWMS M&O), September 22, 2000. ACC: MOL.20001025.0091.

Miller, W.M. and Chapman, N.A. 1993. *HMIP Assessment of Nirex Proposals, Identification of Relevant Processes (System Concept Group Report).* Technical Report IZ3185-TR1 (Edition 1). [London], United Kingdom: Her Majesty's Inspectorate of Pollution (HMIP), Department of the Environment. TIC: 238458.

NAGRA (Nationale Genossenschaft fur die Lagerung Radioaktiver Abfalle) 1994. *Kristallin-I, Safety Assessment Report.* NAGRA Technical Report 93-22. Wettingen, Switzerland: National Cooperative for the Disposal of Radioactive Waste. TIC: 235964.

NRC (U.S. Nuclear Regulatory Commission) 1999. *Issue Resolution Status Report Key Technical Issue: Structural Deformation and Seismicity.* Rev. 2. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.19991214.0623.

NRC (U.S. Nuclear Regulatory Commission) 2000. *Issue Resolution Status Report Key Technical Issue: Total System Performance Assessment and Integration.* Rev. 3. [Washington, D.C.]: U.S. Nuclear Regulatory Commission. TIC: 249045.

Nuclear Energy Agency 1992. *Systematic Approaches to Scenario Development: A Report of the NEA Working Group on Identification and Selection of Scenarios for Performance Assessment of Nuclear Waste Disposal.* Paris, France: Nuclear Energy Agency, Organization for Economic Cooperation and Development. TIC: 8083.

Pickett, D.A. and Leslie, B.W. 1999. *An Audit of the U.S. Department of Energy Treatment of Features, Events, and Processes at Yucca Mountain, Nevada, with Emphasis on the Evolution of the Near-Field Environment.* [San Antonio, Texas]: Center for Nuclear Waste Regulatory Analyses. TIC: 248177.

SAM (Safety Assessment Management) [1997]. Safety Assessment of Radioactive Waste Repositories, An International Database of Features, Events and Processes. Unpublished Draft, June 24, 1997. ACC: MOL.19991214.0522.

7.2 CODES, STANDARDS, REGULATIONS, AND PROCEDURES

Procedures listed below are retreivable from the OCRWM Program Documents database contained in Lotus Notes 4.6 and the BSC INTRANET.

AP-2.21Q, REV. 1, ICN 0, BSCN 1. *Quality Determinations and Planning for Scientific, Engineering, and Regulatory Compliance Activities.* Washington, DC: U.S. Department of Energy, Office of Civilian Radioactive Waste Management.

AP-3.10Q, REV. 2, ICN 3, BSCN 1. *Analyses and Models.* Washington, DC: U.S. Department of Energy, Office of Civilian Radioactive Waste Management.

AP-3.11Q, REV. 1, ICN 3, BSCN 1. *Technical Reports.* Washington, DC: U.S. Department of Energy, Office of Civilian Radioactive Waste Management.

AP-SI.1Q, REV. 2 ICN 4, ECN 1. *Software Management.* Washington, DC: U.S. Department of Energy, Office of Civilian Radioactive Waste Management.

AP-SV.1Q, REV. 0, ICN 2. *Control of the Electronic Management of Information.* Washington, DC: U.S. Department of Energy, Office of Civilian Radioactive Waste Management.

YAP-SV.1Q, REV. 0, ICN 1 (DC #22175) (C) *Control of the Electronic Management of Data.* Washington, DC: U.S. Department of Energy, Office of Civilian Radioactive Waste Management.

APPENDIX A

GLOSSARY

INTENTIONALLY LEFT BLANK

APPENDIX A - GLOSSARY

Classification (Layer, Category, Heading) Entry– Database entries that represent the hierarchical levels of classification within the database. Classification entries are neither primary FEPs nor secondary FEPs. They are defined too broadly to be addressed by a single screening discussion (as with a primary FEP) and cannot be encompassed by overlying FEP (as with a secondary FEP). Rather, they classify one or more underlying related primary FEPs and do not require screening discussions.

Database– A collection of information in a single database file or in a set of related database files.

Disruptive FEP–A retained FEP that has a probability of occurrence during the period of performance less than 1.0 (but greater than the cutoff of $10^{-4}/10^{4}$ year)

Disruptive scenario–Any scenario that contains all expected FEPs and one or more disruptive FEPs.

Event–A natural or anthropogenic phenomenon that has a potential to affect disposal system performance and that occurs during an interval that is short compared to the period of performance.

Excluded FEP - A FEP that is identified by the FEP screening process as not requiring analysis based on specific criteria provided by the regulations.

Expected FEP –A retained FEP that, for the purposes of the TSPA, is assumed to occur with a probability equal to 1.0 during the period of performance.

Feature–An object, structure, or condition that has a potential to affect disposal system performance.

FEP–A feature, event, or process.

Field (Database Field)– The basic unit of data entry in a record. One of several blocks of information (data/text) contained in a record.

Included FEP– A FEP that is identified by the FEP screening process as requiring analysis in the quantitative TSPA.

Nominal scenario – The scenario that contains all expected FEPs and no disruptive FEPs.

Primary FEPs– FEPs that encompass a single process or event, or a few closely related or coupled processes or events that can be addressed by a specific screening discussion. Each primary FEP is addressed by a YMP-specific screening discussion taken from one or more FEP AMRs. A primary FEP may also include one or more related secondary FEPs that are covered by the same screening discussion.

Process–A natural or anthropogenic phenomenon that has a potential to affect disposal system performance and that operates during all or a significant part of the period of performance.

Record (Database Record)– One set of fields in a database. Each record contains data about a single FEP.

Retained FEP–A FEP that is identified by the screening process as requiring analysis in the quantitative TSPA.

Secondary FEPs– FEPs that are (1) redundant to another FEP (e.g., several NEA contributors identified the same FEP), (2) specific to another program (and captured more generally in a different YMP-specific FEP), or (3) better captured or subsumed in another similar but more broadly-defined YMP-specific FEP. Each secondary FEP is mapped to a primary FEP and must be completely addressed by the screening discussion of that primary FEP.

Scenario–A subset of the set of all possible futures of the disposal system that contains futures resulting from a specific combination of FEPs.

Scenario class–A set of scenarios that share sufficient similarities that they can usefully be aggregated for the purposes of a specific analysis.

Screening Argument– A summary discussion of the technical basis for the Screening Decision.

Screening Decision– A statement of whether the FEP is included in the quantitative TSPA models or excluded from the TSPA on specific criteria provided by the regulations.

TSPA Disposition– A summary discussion of the treatment of an included FEP in the TSPA.

APPENDIX B

MACHINE READABLE MEDIA ATTACHMENT - COMPACT DISC CONTAINING DATABASE AND SUPPLEMENTARY FILES FOR YMP FEPS DATABASE REV 00 ICN 01

INTENTIONALLY LEFT BLANK

APPENDIX B - MACHINE READABLE MEDIA ATTACHMENT - COMPACT DISC CONTAINING DATABASE AND SUPPLEMENTARY FILES FOR YMP FEPS DATABASE REV 00 ICN 01

FILE LISTING

The compact disc attached in this Appendix contains the file SetupFEPS.exe. The SetupFEPS.EXE file is a compressed file used to install the FEP database and ancillary files. Execution of SetupFEPS.exe installs all the files needed to view the YMP FEPs Database REV 00 ICN 01 using Microsoft Access 97.

Installation of the FEP database requires Windows 98 or Windows NT 4 operating systems. The default directory for installation is C:\Program Files\FEPS. To run the FEPs database, select Start\Programs\YMP FEP Database\FEPs00_ICN01, which will open REV 00 ICN 01 in Microsoft Access 97.

A listing of the files compressed in SetupFEPS.exe is provided in Table B-1. All files on the electronic record have a QA designator of QA:QA.

Table B-1. List of Files for YMP FEP Database REV 00 ICN 01

Filename	Application	File Description
FEPs00_ICN01.mde	Microsoft Access 97	REV 00 ICN 01 of Database
FEPIntro00__ICN01.doc	Microsoft Word 97	Introductory text for REV 00 ICN 01
FEPUser00_ICN01.doc	Microsoft Word 97	User documentation for REV 00 ICN 01
SYS ANL-WIS-MD-000019 REV 00.doc	Microsoft Word 97	Systems AMR
SZ ANL-NBS-MD-000002 REV 01.doc	Microsoft Word 97	Saturated Zone AMR
DE ANL-WIS-MD-000005 REV 00 ICN 1.doc	Microsoft Word 97	Disruptive Events AMR
WFMisc ANL-WIS-MD-000009 REV 00 ICN 01.doc	Microsoft Word 97	Waste Form Miscellaneous AMR
BIO ANL-MGR-MD-000011 REV 01.doc	Microsoft Word 97	Biosphere AMR
NFE ANL-NBS-MD-000004 REV 00 ICN 01.doc	Microsoft Word 97	Near Field Environment AMR
WFClad ANL-WIS-MD-000008 REV 00 ICN 01.doc	Microsoft Word 97	Waste Form Cladding AMR
UZ ANL-NBS-MD-000001 REV 01A.doc	Microsoft Word 97	Unsaturated Zone AMR
WFCol ANL-WIS-MD-000012 REV 00 ICN 01.doc	Microsoft Word 97	Waste Form Colloids AMR
WP ANL-EBS-PA-000002 REV 01.doc	Microsoft Word 97	Waste Package AMR
EBS ANL-WIS-PA-000002 REV 01.doc	Microsoft Word 97	Engineered Barrier System AMR
EBS ANL-WIS-PA-000002 REV 01 ATCH 1.doc	Microsoft Word 97	Engineered Barrier System AMR, Attachment 1
EBS ANL-WIS-PA-000002 REV 01 TAB 1.doc	Microsoft Word 97	Engineered Barrier System AMR, Tab 1

Table B-1. List of Files for YMP FEP Database REV 00 ICN 01 (cont.)

Filename	Application	**File Description**
EBS ANL-WIS-PA-000002 REV 01 TAB 2,3.doc	Microsoft Word 97	Engineered Barrier System AMR, Tabs 2 and 3
EBS ANL-WIS-PA-000002 REV 01 TAB 4.5.doc	Microsoft Word 97	Engineered Barrier System AMR, Tabs 4 and 5
EBS ANL-WIS-PA-000002 REV 01 TAB 6,7.doc	Microsoft Word 97	Engineered Barrier System AMR, Tabs 6 and 7
EBS ANL-WIS-PA-000002 REV 01 TAB 8.doc	Microsoft Word 97	Engineered Barrier System AMR, Tab 8
EBS ANL-WIS-PA-000002 REV 01 TAB 9.doc	Microsoft Word 97	Engineered Barrier System AMR, Tab 9
EBS ANL-WIS-PA-000002 REV 01 Figs 1,1A,2,2A.doc	Microsoft Word 97	Engineered Barrier System AMR, Figures 1, 1A, 2, and 2A
EBS ANL-WIS-PA-000002 REV 01 Figs 3 to 6.doc	Microsoft Word 97	Engineered Barrier System AMR, Figures 3 through 6
EBS ANL-WIS-PA-000002 REV 01 Figs 7 to 8A.doc	Microsoft Word 97	Engineered Barrier System AMR, Figures 7 through 8A
comcat.dll	Windows 98/NT	Microsoft Component Catalog Manager Library
comctl32.ocx	Windows 98/NT	Microsoft WIndows Common Controls
condlg32.ocx	Windows 98/NT	Microsoft Common Dialog Control