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CR 99/008

Revise the Project Baseline to Add and Delete Work Scope, Budget, and Milestones for Process Models and Data Qualification (PMDQ) and Enhanced Design Alternative (EDA) II

Volume 3

Copy of Approved Change Request

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Section 11
Responses to 3/25/99 Guidance Letter
Table of Contents

Summary of Responses to 3/25/99 Requirements

1) a)

Summary of Responses to 3/25/99 Requirements

This section contains responses to the requirements contained in the March 25, 1999, letter from Dr. J. Russell Dyer, YMSCO Project Manager, to Dr. D.R. Wilkins, M&O AGM, specifying guidance for this Change Request.

This section contains the following:

Requirements/Products Matrix — lists the requirements contained in the 3/25/99 guidance letter and where they are addressed in this CR submittal

PMR Description — describes the structure and content of the Process Model Reports that will be used to support/prepare the SR report and the LA

PMR Logic Diagrams — pictorial representations of how underlying AP-3.10Q analysis reports and data/model/code sets support each of the nine PMRs

PMR Annotated Outlines — outlines of the contents of each of the nine PMRs

AP-3.10Q Report Scope Statements — synopsis of the contents of each AP-3.10Q report

Key Documents Supporting SR/LA — table of how the PMRs, SDDs, and other key documents are used to support/build sections of the SR report and LA

PMR Cost Table — estimate of the cost of preparing each PMR and its supporting AP-3.10Q analyses

Data Qualification Plan and Status — status of the plan for qualifying the technical data, models, and software needed for SR/LA

Tiger Team and Their Goals — list of the Tiger Teams identified to date and their goals, which will determine the specific minimum necessary and sufficient data sets for SR/LA

Deliverable Deletion Rationale Matrix — documentation of concurrence of the disposition of deliverables being altered/deleted by this change request

Requirements/Products Matrix

1) b)

Item #	Requirements from 3/25/99 PMDQ CR Guidance Letter	CR Document Addressing Requirement
1	The PMRs should focus only on the documentation of the technical basis for the process models used in postclosure performance assessment.	PMR Description
2	They (PMRs) should contain no regulatory conclusions or compliance arguments, . . .	PMR Description
3	. . . they (PMRs) should not be prepared for conversion to topical reports.	PMR Description
4	The depth and breadth of scientific and engineering work that relates to the assessment of post closure performance and that will be used in preparing the SR Report and LA must be adequately represented in the PMRs, and in supporting Administrative Procedure (AP) 3.10Q analyses and other documents.	PMR Description
5	The PMRs and the AP-3.10Q analyses, as appropriate, must take full advantage of and adequately reflect the body of existing scientific work on the Project by direct reference, as is normally done within the scientific and technical community.	PMR Description, PMR Annotated Outlines
6	The PMRs must provide sufficient support for the conclusions and models presented to be credible and defensible, and to withstand rigorous technical review.	PMR Description, PMR Annotated Outlines
7	The PMRs should be based on the best available information and provide a roadmap to that information, both in the Technical Data Management System (TDMS) and available reports.	PMR Description, PMR Annotated Outlines
8	In order to adequately define the scope of the PMR effort, the CR needs to: contain an outline of each PMR that is sufficiently detailed to convey the scope of the document; . . .	PMR Annotated Outlines
9	In order to adequately define the scope of the PMR effort, the CR needs to: . . . Identify the number and scope of the AP-3.10Q analyses that may be required to support each PMR; . . .	PMR Logic Diagrams, AP-3.10Q Report Scope Statements
10	In order to adequately define the scope of the PMR effort, the CR needs to: . . . identify the data, including existing data, analyses, and interpretations, that are likely to be considered in preparing the PMRs and supporting APR-3.10Q analyses; . . .	PMR Logic Diagrams, AP-3.10Q Report Scope Statements
11	In order to adequately define the scope of the PMR effort, the CR needs to: . . . to the extent possible, indicate which data, analyses and interpretations contained in existing references are likely to require qualification or other action prior to use and provide a detailed plan for this effort; . . .	Data Qualification Plan and Status, Tiger Teams and Their Goals
12	In order to adequately define the scope of the PMR effort, the CR needs to: . . . provide a list of other documentation, data, and models that may be addressed or a schedule for providing the information in each PMR.	PMR Annotated Outlines, Schedule
13	An appropriately detailed cost estimate for the work required in preparing each PMR and the associated AP-3.10Q documentation must be provided so that there is a basis to evaluate the scope of the proposal.	PMR Cost Table
14	A schedule for development of the PMRs and the associated AP-3.10Q analyses and supporting data also needs to be provided.	Schedule

Item #	Requirements from 3/25/99 PMDQ CR Guidance Letter	CR Document Addressing Requirement
15	The linkages between each PMR and its supporting AP-3.10Q analyses, existing scientific data and analyses, and other information should be defined to the extent possible.	PMR Logic Diagrams, Schedule
16	The linkages between each PMR and its supporting AP-3.10Q analyses, existing scientific data and analyses, and other information should be defined to the extent possible.	AP-3.10Q Report Scope Statements, Schedule
17	The relationship of the CR and the PMRs to plans for development or completion of other documents, including the Seismic Hazard Topical Reports, the Disposal Criticality Topical Report, and separate reports on disruptive events and natural analogs, also needs to be described.	Schedule
18	The schedule must indicate how the PMRs will support the process and schedule for development of the draft SR Report and draft LA chapters.	Schedule
19	DOE review of the CR will focus heavily on the details of the logic in the schedule.	Schedule
20	The CRWMS M&O should provide a matrix showing how the PMRs support preparation of the relevant postclosure sections of the SR Report and LA.	Key Documents Supporting SR/LA
21	The matrix should also indicate where other documents are required to provide the necessary information (e.g., TSPA, Site Description).	Key Documents Supporting SR/LA
22	Since the proposed PMR process focuses entirely on the documentation needed for postclosure evaluations, the CR should indicate how the PMR process and other proposed changes relate to existing plans to provide the other information (e.g., on design and pre closure radiological safety) that is required for the SR Report and LA.	None. No significant impact anticipated.
23	The CR should clearly note any changes in the work planned to provide the information needed for design and preclosure safety analyses.	None. No significant impact anticipated.
24	The CR needs to provide DOE with a detailed schedule and specific goals of the Tiger Team efforts related to each PMR, and an estimate of the costs associated with these efforts for each PMR so that there is a basis to understand the scope of the effort and to identify those areas that require the greatest expenditure of resources.	Schedule, Tiger Teams and Their Goals
25	The Tiger Team schedules need to be integrated with the PMR development schedule so that the overall PMR schedule can be evaluated.	Schedule
26	Additional technical reviews, data qualification activities, and formal peer reviews that may be required, as identified by the Tiger Teams, should not be planned as part of this CR, but should be included in future CRs as the needs are identified.	N/A
27	The deletion or disposition of planned fiscal year (FY) 1998 and FY 1999 Level 3 Deliverables should be discussed with and must be agreed upon by the Yucca Mountain Site Characterization Office (YMSCO) Assistant Manager (AM) affected as part of CR development.	Deliverable Deletion Rationale Matrix

Item #	Requirements from 3/25/99 PMDQ CR Guidance Letter	CR Document Addressing Requirement
28	A rationale for each Level 3 deliverable deletion agreed upon by the affected YMSCO AM needs to be included in the CR. The rationale should include a discussion of where the data or information will be captured, a schedule for when this event will occur, and an estimate of the cost savings associated with deliverable deletion (i.e., a cost-benefit analysis for the deletion as opposed to completing it according to the present plan).	Deliverable Deletion Rationale Matrix
29	Absent a clear benefit to deleting the deliverable, the work should be completed as originally planned.	Deliverable Deletion Rationale Matrix
30	Rather than accept the proposed treatment of the PMRs as a new sub product, with a separate sub-product element for each PMR, as a basis for CR development, DOE prefers that the CR effort focus on the detailed integration of the schedule and scope for PMR development, and the relationship of the PMRs to other project documents and activities.	Schedule, PMR Description, PMR Logic Diagrams, Key Documents Supporting SR/LA
31	Once this (CR planning) effort has begun, it should be possible for the planning team to identify where the proposed activities logically fall in the Project Work Breakdown Structure. Two weeks after the receipt of this guidance, the planning team should report to Victor W. Trebules, Director, Office of Project Control, with a proposal for DOE approval regarding the planning structure for reporting and monitoring work related to these new activities.	Completed via 4/16/99 email from Harbert to Summerson
32	We (DOE) remain concerned that the cost estimate to re-focus the FY 1999 CRWMS M&O work plan on high priority tasks needed to develop the documentation and traceability required for the SR Report and the LA has grown since the original proposal presented on February 4, 1999. We suggest that the final cost associated with the CR be constrained to the $8.7 million estimate contained in the above-referenced letter.	Budget and Cost Back Up Tables
33	The CR needs to contain a detailed schedule which shows all necessary and appropriate technical feeds to the final Environmental Impact Statement (EIS) under the new construct, and most importantly, demonstrates how the CRWMS M&O will assure technical and design consistency between the final EIS and SR.	Schedule
34	The proposed schedule for PMR development (as indicated in the above-referenced letter) shows that verification and traceability activities will be completed by the end of FY 1999.	Schedule
35	Before approving the FY 2000 plan, the DOE will need to have a good understanding of what additional information must be collected or other work completed to support the PMRs.	Schedule
36	To approve the CR, DOE will also need to understand, in detail, the differences, if any, in scope, cost, or schedule, between the work discussed in Volume 4 of the VA and the work planned for FY 1999, 2000, and the out years to achieve SR and LA under this new construct.	VA Document Cross-walk (to be submitted week of 5/24/99)

PMR Description

1) c) i)

Description of Process Model Report Concept

Purpose

The purpose of a Process Model Report (PMR) is to document a synthesis of the necessary and sufficient technical information that the Project will be relying upon to support its site suitability evaluation and the licensing safety case pertaining to a particular process model. The technical information consists of data, analyses, models, software, and supporting documentation used to defend the applicability of the model for its intended purpose of evaluating the postclosure performance of the Yucca Mountain repository system.

Scope of Reports

A Process Model Report will be developed for each of the nine topics identified below:

1. Integrated Site Model
2. Unsaturated Zone Flow and Transport
3. Saturated Zone Flow and Transport
4. Near Field Environment
5. Waste Package Degradation
6. Waste Form Degradation
7. Engineered Barrier System Degradation and Flow/Transport
8. Biosphere
9. Tectonic Hazards

The Process Model Reports will incorporate the results of the model validation and traceability effort currently underway, as well as reflect the analyses and modeling documentation to be developed under the AP-3.10Q process, *Analyses and Models*. Each Process Model Report will address the following aspects related to the particular process model being addressed:

- Description of the model and submodels
- Abstraction of the model into TSPA
- Relevant data and data uncertainties
- Assumptions and bases
- Model results (outputs)
- Information on code verification/model validation
- Opposing views
- Information necessary to support regulatory evaluations

PMR Development

As indicated in the purpose statement above, each Process Model Report will be a synthesis report. These reports, estimated to be on the order of 200-300 pages each, will primarily reference supporting AP-3.10Q analyses and modeling documentation, documents developed outside the Project, and other key documents (e.g., Topical Reports and other Process Model Reports). However, the intent is to minimize reference to other internal Project reports, to the extent practicable. Such reports may be considered for referencing on a case-by-case basis.

Figure 1 illustrates the PMR development concept. Each of the analyses and models that are related to a particular Process Model Report will be documented in accordance with AP-3.10Q. This documentation will be summarized in the Process Model Report, but will not be physically part of the report. The Process Model Report itself will be developed using procedure AP-3.11Q, *Technical Reports*.

In developing each Process Model Report, and the supporting analyses and models, the subject matter experts will be cognizant of existing documentation (internal and external) that is related to the process model being addressed. The information in these related documents will be evaluated and dispositioned in one of the following ways:

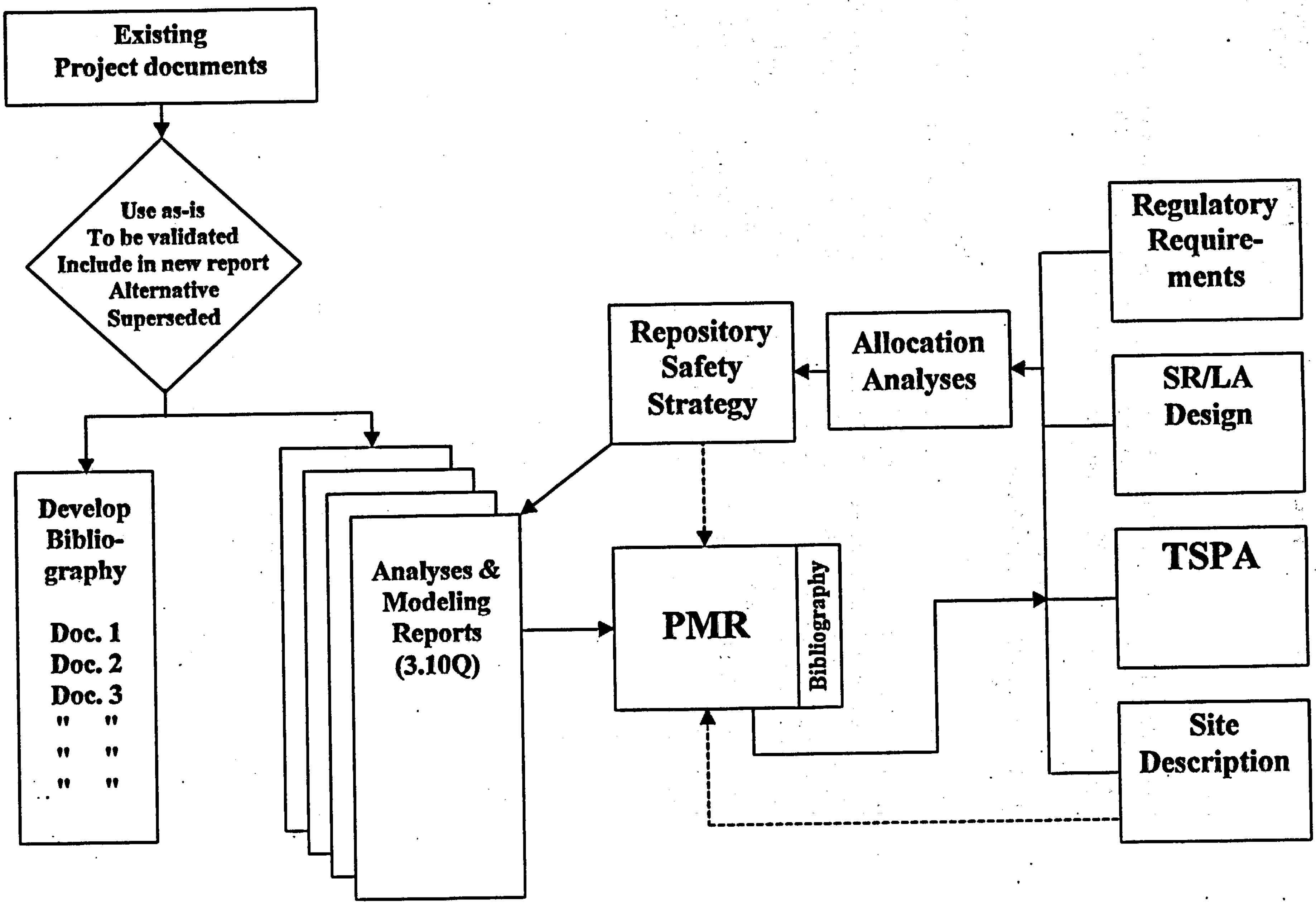
- Use as is
- To be validated
- Include in new analysis and modeling (3.10Q)/technical report (3.11Q)
- Alternative interpretation
- Superseded

The purpose of this evaluation is to provide objective evidence that the depth and breadth of the technical information available on a particular process model has been adequately considered. For further detail on this process, refer to Appendix A.

These Process Model Reports will be developed using the "To Be Verified (TBV)" tag for that information that needs further work (e.g., data that need to be qualified). The Process Model Reports will contain TBVs primarily because the subordinate AP-3.10Q analyses and model reports contain TBV information. The principal task in going from Rev. 00 of the analyses and model reports to subsequent revisions will be removing the TBVs and conducting appropriate controlled impact analyses per AP-3.10Q. The goal is to eliminate these TBVs as much as possible by the time the Site Recommendation is submitted to the President (July 2001).

There is also an iterative allocation process involved in the development of the PMRs and supporting analysis and model reports. The allocation process takes into account the regulatory requirements, the current SR/LA design, the TSPA results based on that design, and what is know about the site characteristics. This information allows an evaluation of the various components of the system to determine the importance of each of these components in supporting the postclosure safety case. This evaluation would be reflected in the Repository Safety Strategy and be used to drive the level of analysis or modeling needed to support each of the PMRs.

Figure 1 - PMR Development



PMR Team

The PMRs will be developed using an integrated matrix management concept that draws expertise from various elements of the M&O organization. The personnel listed below have been assigned responsibility for development of the PMRs:

PMR Manager – Mike Lugo
PMR Production Coordinator – Steve Kopelic

PMR	PMR Lead	PA Representative	Regulatory Representative
Integrated Site Model	Clinton Lum	Cliff Ho	Terry Crump
Unsaturated Zone Flow/Transport	Bo Bodvarsson	Cliff Ho	Martha Pendleton
Saturated Zone Flow/Transport	Al Eddebbarh	Bill Arnold	Augie Matthusen
Near Field Environment	Debra Bryan	Nick Francis	Pete Gaillard
Waste Package Degradation	Joe Farmer	Joon Lee	Ali Haghi
Waste Form Degradation	Christine Stockman	Rob Rechard	Mike Scott
EBS Degradation/Flow/Transport	Dwayne Chesnut	Bob McKinnon	Dale Geiger
Biosphere	John Schmitt	Tony Smith	Kayce Prince
Tectonic Hazards	Richard Quittmeyer	Rally Barnard	Terry Crump

APPENDIX A

Document Evaluation Process

Background

The purpose of the Process Model Reports (PMRs) is to document the technical basis supporting each Total System Performance Assessment (TSPA) process model and thereby support the postclosure site suitability evaluation and the postclosure safety case for licensing. The PMR development process is intended to ensure traceability of data, information, and references that form the basis to demonstrate compliance with postclosure requirements.

Each PMR has an associated suite of Analyses and Modeling Reports (AP-3.10Qs) that are intended to collect, evaluate, and interpret information (data, hypotheses and assumptions, and other details) related to the specific PMRs. A key component of the information is the identification of existing Project and external documents that may be relevant to each PMR. This appendix describes the process to be used to evaluate existing documents and determine their relevance to PMRs.

Summary of Document Evaluation Process

The purpose of the document evaluation process is to provide objective evidence of those existing documents that were reviewed for relevancy in preparing each PMR and complete an evaluation of the documents for disposition into one of five action status categories:

- **Use As Is**
- **To Be Validated**
- **Include In A New Analysis and Modeling Report (AP-3.10Q)/Technical Report (AP-3.11Q)**
- **Alternative Interpretation**
- **Superseded**

The disposition process will include development of annotations that describe the relevance of each document to its associated PMR. This process starts with the author of each PMR, Analysis and Model Report and Technical Report preparing a bibliography listing all documents that were used /considered /reviewed in preparing the Analysis and Model Report or Technical Report. The author will complete a form for each bibliographic entry that 1) identifies the document used/considered/reviewed, 2) indicates which of the five categories, identified above, applies to this document and 3) provides the rationale for assigning the document to the category indicated. Personnel formally assigned to check the Analysis and Model Reports, the Technical Reports, and the PMR leads are expected to add to the bibliographic record by providing information to complete the same form used by the Analysis and Model Report/ Technical Report authors. The authors, checkers and PMR leads are expected to be subject matter experts with sufficient project experience to be knowledgeable of the subject matter discussions that are intended for the Site Recommendation and the License Application. The authors, checkers and PMR leads are also expected to be knowledgeable of the content of Project and external documents that may be relevant to the PMR topic.

The rationale for assigning a document to one of the five categories shall be based on the category descriptions below:

Use As Is: Documents in this category have been reviewed by a Project subject matter expert exercising professional judgment and found to contain information relevant to the PMR topic. The information is expected to support the safety case for the Site Recommendation (SR) or the License Application (LA). Alternatively, the document may not be needed for direct support of the safety case, but the information is needed to demonstrate adequate understanding of some natural or engineered component of the repository system, including information needed to address NRC Key Technical Issue (KTI) acceptance criteria. Review of the document has determined that the document complies with relevant quality and traceability requirements.

Annotations for documents in this category will identify the documents as relevant to a specified PMR, identify the information needed to support the SR or the LA; describe how the information is expected to support the SR or the LA, or describe how the information is needed to address KTI acceptance criteria. The annotation will also identify the procedure(s) used to develop the document and briefly describe the basis for considering the document suitable for use without modification.

To Be Validated: Documents in this category have been reviewed by a Project subject matter expert exercising professional judgment and found to contain information relevant to the PMR topic. The information is expected to support the safety case for the Site Recommendation or the License Application. Alternatively, the document may not be needed for direct support of the safety cases but may be used as collaborative information needed to demonstrate adequate understanding of some natural or engineered component of the repository system, including information needed to address NRC Key Technical Issue (KTI) acceptance criteria. Review of the document has determined that the document does not comply with relevant quality and traceability requirements. Therefore, the document must be updated to meet relevant quality requirements; this update is intended to be minor. If the update cannot be accomplished, then the information necessary to support the safety case needs to be validated and included in a new Analyses and Modeling Report (AP-3.10Q) or Technical Report (AP-3.11Q) as described below.

Annotations for documents in this category will identify the documents as relevant to a specified PMR; identify the information as needed to support the Site Recommendation or License Application; describe how the information is expected to support the Site Recommendation or the License Application or describe why the information is needed to address KTI acceptance criteria. The annotation will also describe how the information will be updated to provide a fully validated document, including the procedure(s) that will be used to develop the upgrade.

Include In A New Analysis and Modeling Report (AP-3.10Q)/ Technical Report (AP-3.11Q): Documents in this category have been reviewed by a Project subject matter expert exercising professional judgment and found to contain information necessary to support a PMR topic. The information is also expected to be needed to support the safety case for the Site Recommendation or the License Application, or to address KTI acceptance criteria. The relevant information in the document must be extracted from an existing document that is not fully citable and recompiled in a new Analysis and Modeling/ Technical Report.

Annotations for documents in this category will identify the documents as relevant to a specified PMR, identify the information needed to support the SR or the LA; describe how the information is expected to support the SR or the LA; or describe how the information is needed to address KTI acceptance criteria. The annotation will also describe how the information will be updated to provide a validated Analysis and Model Report (AP-3.10Q) or Technical Report (AP-3.11Q), including the procedure(s) that will be used to develop the upgrade.

Alternative interpretation: Documents in this category have been reviewed by a Project subject matter expert exercising professional judgment and found to contain information relevant to the PMR topic, but representing alternative interpretations not endorsed by the Project. Documents in this category are expected to include those that represent viable alternative interpretations, but they may include interpretations that have been widely discounted by Project or other work.

Annotations for documents in this category will identify the documents as expressing an alternative interpretations not endorsed by the Project and describe the basis for the non-endorsement by the Project.

Superseded: Documents in this category may have been initially believed to be potentially relevant to a PMR. Upon review by a Project subject matter expert exercising professional judgment, these documents were found to contain information no longer relevant to the PMR topic.

Annotations for documents in this category will identify the document as not applicable to the PMR topic and briefly explain the basis for the classification of no longer considered relevant to the PMR topic.

Discussion

It is expected that the reviews, evaluations, and development of the annotated bibliographies will occur as part of the development of the Analyses and Modeling reports associated with the various PMRs. The products of this process are expected to be nine comprehensive annotated bibliographies, one for each PMR, describing the disposition into one of five categories of all documents that were initially believed to be relevant to each PMR. The annotations will briefly describe the relevance of the document to a specific PMR, and the basis for updating the document or considering it suitable for use without modification. The annotated bibliographies will then be included with the appropriate PMRs to form a suite of fully validated documents to support the Site Recommendation and the License Application.

PMR Logic Diagrams

1) c) ii)

PMR Annotated Outlines

1) c) iii)

INTEGRATED SITE MODEL

PROCESS MODEL REPORT (PMR)

CHAPTER 1 INTRODUCTION

This section will provide the "up front" information necessary for the reader to understand the purposes of the ISM PMR report, its basic organization, and related issues. It also supports the reader who desires a quick look at the document without reviewing it in great detail.

This section also provides a high-level summary of how the ISM PMR relates to technical topics presented in the other PMRs. The section will contain introductory text that briefly describes the goal of the Yucca Mountain Project:

- To determine suitability of the Yucca Mountain site for disposal of high-level nuclear waste
- If it is found suitable, the goal is to then seek a license to construct and subsequently to operate and close a high-level waste disposal facility

1.0 INTRODUCTION

This section also explains in general why the Process Model Reports (PMR) are being developed, and why this specific PMR is being developed. This discussion will include a summary of previous treatment of the subject issue (background of previous modeling).

Finally, the section summarizes the layout of the ISM PMR.

1.1 OBJECTIVE

This section provides the objective of the PMR (what its production is intended to accomplish). Briefly and generically, the objective is to integrate and summarize information on the models, analyses, data, and abstractions that are intended to support Total System Performance Assessment (TSPA) on the PMR's subject. The document serves as an important reference to the license application and has a similar readership (primarily knowledgeable persons in technical and regulatory fields). Many of the objectives are common to all the PMRs, though one or more may also be specific to a given PMR.

1.2 SCOPE

This section explains the information presented in and the content of the PMR. It will be a high-level discussion and will use one or more flowcharts to show the evolution of information from data to TSPA output, showing in the flowcharts what parts of the evolution are included in the ISM PMR. The section also describes where to find relevant subject matter not included in the PMR (i.e., the AP3.10Qs). The discussion will include an illustration showing the relationship between the PMR and the constituent sub-models, documented under AP 3.10Q and a description of how the PMR will be used in addressing its subject in the Site Recommendation Report (SRR) and the License Application.

The scope of the ISM PMR will be to describe the framework for discussing the geologic properties of the site (e.g., stratigraphy, structural characteristics, geohydrologic rock properties, and mineralogy). The PMR describes how geophysical and hydrologic property information has been used to characterize the geologic properties of the site. The report also describes how the output from the ISM is used as input to the unsaturated zone (UZ) flow and transport model, the saturated zone (SZ) flow and transport model, tectonic hazards, and engineered barrier system (EBS) design.

1.3 QUALITY ASSURANCE

This section explains the quality assurance controls under which the ISM PMR was developed (QA controls under which both the report and models were prepared). The PMR is expected to be determined to be quality-affecting through QAP-2-0 analysis. As such it is to be developed under AP-3.11Q. The section also discusses the method through which non-Q data and references have been upgraded for incorporation in the PMR via the constituent models and analyses developed in compliance with AP-3.10Q. And it discusses how non-Q data referred to in the document are tracked with "TBVs." This section provides a general discussion, with the more specific demonstrations of compliance with quality assurance requirements to follow in later chapters and to be discussed in the referenced AP-3.10Q analyses.

1.4 RELATIONSHIP TO OTHER PROCESS MODEL REPORTS AND PROJECT DOCUMENTS

This section discusses how this PMR relates to the others in terms of interfaces and overlaps. It will include a list of all these PMRs and a summary-level purpose of each. The section explains how the ISM PMR relates to:

- Documents such as the Yucca Mountain Site Description, the SRR, the LA, and other documents considered applicable and appropriate by the PMR authors

- Other contributory or subsequent process models.

1.5 OVERVIEW DESCRIPTION AND RESULTS OF THE INTEGRATED SITE MODEL AND ITS COMPONENT MODELS

This section provides a high-level description of the models, the abstractions of the models, the results of abstractions and application of the models in the ISM PMR and supporting information that is contained in detail in chapters 3 through 6 and the referenced AP-3.10Q analyses. This is intended to support the reader who wants to get the gist of the report without examining it in great detail. The section also contains a summary of the chapter that integrates the PMR models, abstractions, and analyses (i.e., synthesis of ISM from the three component models).

1.5.1 Geologic Framework Model

This section provides a high-level description of the Geologic Framework Model, the abstractions of the model the results of abstractions and application of the model in the ISM PMR and supporting information that is contained in detail in chapters 3 through 6 and the referenced AP-3.10Q analyses.

1.5.2 Rock Properties Model

This section provides a high-level description of the Rock Properties Model, the abstractions of the model the results of abstractions and application of the model in the ISM PMR and supporting information that is contained in detail in chapters 3 through 6 and the referenced AP-3.10Q analyses.

1.5.3 3D Mineralogic Model

This section provides a high-level description of the 3D Mineralogic Model, the abstractions of the model the results of abstractions and application of the model in the ISM PMR and supporting information that is contained in detail in chapters 3 through 6 and the referenced AP-3.10Q analyses.

1.5.4 Integrated Site Model

The section also contains a summary description of the process that integrates the PMR models, abstractions, and analyses (i.e., synthesis of ISM from the three component models).

CHAPTER 2 EVOLUTION OF THE INTEGRATED SITE MODEL

This chapter provides perspective on the background against which the ISM PMR is being developed and describes the documentation structure of which the PMR is a part:

- First, the chapter explains the philosophy for developing the PMRs, and why this specific PMR is being developed. (This portion of the section will be largely common to all PMRs.)

- Second, the chapter provides a summary of previous versions of the model and how these earlier versions led to the current version (ISM)

- Finally, the section provides a description of the relationship between the PMR and the constituent sub-process models developed under AP3.10Q. Whereas Section 1.2 will use a flowchart to describe the information flow associated with the subject of the PMR, this chapter discusses the same subject but in terms of the document structure (AP 3.10Qs, the ISM PMR itself, and other documents, as applicable).

2.1 PHILOSOPHY OF PMR DEVELOPMENT

This section will provide a relatively high-level discussion generally discussing the philosophy for developing PMRs and why the ISM PMR is warranted.

2.2 INTEGRATED SITE MODEL DEVELOPMENT HISORY

This section will provide a relatively high-level discussion of the development of the integrated site model. It will include a flow diagram showing the ISM timeline, relevant developments since the inception of ISM, and significant changes (upgrades) to the model over time. Finally, it will provide a brief discussion of how the component model outputs are integrated to form ISM. The section will also tie the PMR with the related AP3.10Qs and will guide the reader to the sections of the PMR related to each of the sub-models.

<Note: Depending on the level of detail in the text, the subheadings may or may not be necessary.>

2.2.1 Geologic Framework Model

This section will contain a high-level discussion of the development of the Geologic Framework Model.

2.2.2 Rock Properties Model

This section will contain a high-level discussion of the development of the Rock Properties Model.

2.2.3 3D Mineralogic Model

This section will contain a high-level discussion of the development of the 3D Mineralogic Model.

2.2.4 Integrated Site Model

This section will document the relevant developments since the inception of ISM, and significant changes (upgrades) to the model over time. It will provide a brief discussion of how the component model outputs are integrated to form ISM. The section will also tie the PMR with the related AP3.10Qs and will guide the reader to the sections of the PMR related to each of the sub-models.

CHAPTER 3 INTEGRATED SITE MODEL

Section 3 provides a general discussion of each of the ISM model components, how each was constructed, and the results and uncertainties. It will not provide the detail the would be provided in the AP 3.10Q documents, but will be presented in sufficient detail to provide a strong general understanding of the model, its construction, and the uncertainties and limitations of the output.

3.1 SUMMARY OF COMPONENTS

This section will provide a roadmap of the PMR document.

3.2 GEOLOGIC FRAMEWORK MODEL

Subsections 3.2.1 through 3.2.8 provide summary descriptions of the Geologic Framework Model 3.1 (GFM3.1). All sections will refer back to the GFM3.1 analysis (AP-3.10Q) report.

<Note: The subheadings for Construction and Results are based on the current draft ISM report. They may be scaled back for the PMR as the level of detail for the PMR is defined.>

3.2.1 Introduction

Section 3.2.1 introduces GFM3.1 and illustrates the relationship between this component and the other ISM components. It also describes the layout of the section.

3.2.2 Geologic Framework Model Description

This section provides a description of the model consistent with the corresponding AP-3.10Q report, including its supporting codes, components, sub-models, and/or analyses.

3.2.3 Input Data and Qualification Status

This section summarizes the input data for construction of the GFM, and references the AP-3.10Q. The qualification status of these data is discussed, including methods used to qualify the data. The discussion also includes the qualification of software used to construct the model

3.2.4 Geologic Framework Model Validation

This section demonstrates the validity of the model for its intended application. It includes demonstration of the validity of the data used to support the model validation, as well as demonstration of the validity of the codes that support the models. Results of peer review used to support model validation are included.

Since model validation, per se, is not applicable to the ISM, a brief statement will be included here that the model will be peer reviewed. An explanation of why *model validation* is not applicable to this type of model will also be provided.

<Note: This explanation will also be provide for 3.3.4 and 3.4.4.>

3.2.5 Construction of the Model

This section summarizes the methodology by which the model was constructed.

<Note: This section is based on the "Methodologies" section in the current ISM documentation and in the AP3.10Qs.>

3.2.5.1 Overview of GFM3.1 Methodology

3.2.5.1.1 Grid Construction

3.2.5.1.2 Interpretive Contouring

3.2.5.2 Construction of Faults

3.2.5.3 Construction of Reference Horizons and Isochores

3.2.5.4 Assembly of Faults and Rock Layers

3.2.6 Model Results

This section provides the output of the model; this output is what serves as input to the end users (i.e., UZ or SZ flow and transport models).

3.2.6.1 Interpretation of the Rock Units

3.2.6.1.1 Alluvium and Post-Tiva Units

3.2.6.1.2 Tiva Canyon Tuff (Tpc)

3.2.6.1.3 Paintbrush Tuff nonwelded Unit (PTn)

3.2.6.1.4 Topopah Spring Tuff (Tpt)

3.2.6.1.5 Calico Hills Formation (Tac)

3.2.6.1.6 Prow Pass Tuff (Tcp)

3.2.6.1.7 Bullfrog Tuff (Tcb)

3.2.6.1.8 Tram Tuff (Tct)

3.2.6.1.9 Older Tertiary Unit (Tund)

3.2.6.1.10 Tertiary-Paleozoic Unconformity

3.2.6.2 Interpretation of Faults

3.2.6.2.1 Fault Curvature

3.2.6.2.2 Fault Patterns

3.2.6.2.3 Features of Individual Faults

3.2.6.2.4 Faulting and Deposition

3.2.7 Discussion of Uncertainties and Limitations

This section discusses the uncertainties in the model and the assumptions and how they were derived. It also describes the approach taken to dealing with the uncertainties in the performance assessment (PA).

A brief discussion will also be provided regarding the results of verification exercises that were undertaken during the development of GFM3.1. (Before their respective data were added to the model, elevation data for boreholes SD-6 and WT-24 were compared to the predicted results from the model to evaluate the estimated uncertainty window.)

<Note: In the "typical" PMR outline this section was positioned before Model Validation. It was moved to be after Results to be more consistent with the current ISM report.>

3.2.7.1 Uncertainty Estimates for Constrained Areas

3.2.7.2 Uncertainty Estimates for Less Constrained Areas

3.2.7.3 Limitations of Interpretation

3.2.8 Data Qualification

This section demonstrates the qualification of any data necessary to support use of the model and its sub-models whose qualification has not been demonstrated in the previous sections. Summaries of, and cross-references to, discussions of data pedigrees in AP-3.10Q reports are also provided, as appropriate.

3.2.9 Alternative Interpretations (if applicable)

This section documents credible opposing views to the approaches and methods described in the PMR for the model under discussion. Depending on the best manner of addressing the subject as determined by the PMR authors,

The section consists of a relatively brief summary of the opposing view or position, accompanied by an explanation of why the Project does not subscribe to the opposing view or position. To the extent that compensatory measures have been or will be taken to deal with the opposing view, those measures are also described in this section.

The chapter or section also discusses findings of outside reviewers of the models and processes associated with the PMR, and it describes how the findings have been satisfactorily addressed.

Finally, the chapter or section discusses expert elicitation(s) applicable to the model and/or its abstraction, cross-referencing discussions in previous sections as appropriate.

3.3 ROCK PROPERTIES MODEL

The subsections of the section will be comparable to those in Section 3.2, with reference to the Rock Properties Model 3.1 (RPM3.1) analysis (AP-3.10Q) report. The information provided in the following subsections will be consistent with the related sections in 3.2.

<Note: The subheadings in Sections 3.3.5 and 3.3.6 may be pared back after the necessary level of detail has been evaluated further.>

3.3.1 Introduction

Section 3.3.1 introduces the Rock Properties Model and illustrates the relationship between this component model and the other ISM components. It also describes the layout of the section.

3.3.2 Rock Properties Model Description

This section provides a description of the model consistent with the corresponding AP-3.10Q report, including its supporting codes, components, sub-models, and/or analysis.

3.3.3 Input Data and Qualification Status

This section summarizes the input data for construction of the RPM, and references the AP-3.10Q. The qualification status of these data is discussed, including methods used to qualify the data. The discussion also includes the qualification of software used to construct the model

3.3.3.1 Laboratory Core Porosity Data

3.3.3.2 Computed Petrophysical Porosity Data

3.3.3.3 Laboratory-Measured Secondary Property Data

3.3.3.4 X-ray Diffraction Indicators of Zeolite Alteration

3.3.3.5 Petrophysical Indicators of Hydrous-phase Mineral Alteration

3.3.3.6 Observed (Measured) Lithostratigraphic Contacts

3.3.3.7 Modeled Lithostratigraphic Contacts

3.3.4 Model Validation (Not applicable, see note in 3.2.4)

This section is not applicable; see not in 3.2.4.

3.3.5 Construction of the Model

This section summarizes the methodology by which the model was constructed.

3.3.5.1 Conceptual Model

3.3.5.2 Methodology Overview

3.3.5.3 Simulation of Porosity

3.3.5.4 Modeling of Derivative Properties

3.3.5.5 Calibration and Modeling of Hydrous-phase Mineral Alteration

3.3.5.6 Post-processing of Simulated Models

3.3.6 Model Results

This section provides the output of the model; this output is what serves as input to the end users (i.e., UZ or SZ flow and transport models).

3.3.6.1 Paintbrush Tuff Nonwelded Unit (PTn)

3.3.6.2 Welded Topopah Spring Tuff Unit (TSw)

3.3.6.3 Calico Hills Nonwelded Unit (CHn)

3.3.6.4 Prow Pass Tuff (Tcp)

3.3.7 Discussion of RPM3.1 Uncertainties and Limitations

This section discusses the uncertainties in the model and the assumptions and how they were derived. It also describes the approach taken to dealing with the uncertainties in the performance assessment (PA).

A brief discussion will also be provided regarding the results of verification exercises that were undertaken during the development of RPM3.1. (Before their respective data were added to the model, elevation data for boreholes SD-6 and WT-24 were compared to the predicted results from the model to evaluate the estimated uncertainty window.)

<Note: In the "typical" PMR outline this section was positioned before Model Validation. It was moved to be after Results to be more consistent with the current ISM report.>

3.3.8 Data Qualification

This section demonstrates the qualification of any data necessary to support use of the model and its sub-models whose qualification has not been demonstrated in the previous sections. Summaries of, and cross-references to, discussions of data pedigrees in AP-3.10Q reports are also provided, as appropriate.

3.3.9 Alternative Interpretations

This section documents credible opposing views to the approaches and methods described in the PMR for the model under discussion. Depending on the best manner of addressing the subject as determined by the PMR authors,

The chapter or section consists of a relatively brief summary of the opposing view or position, accompanied by an explanation of why the Project does not subscribe to the opposing view or position. To the extent that compensatory measures have been or will be taken to deal with the opposing view, those measures are also described in this section.

The chapter or section also discusses findings of outside reviewers of the models and processes associated with the PMR, and it describes how the findings have been satisfactorily addressed.

Finally, the chapter or section discusses expert elicitation(s) applicable to the model and/or its abstraction, cross-referencing discussions in previous sections as appropriate.

3.4 3D MINERALOGIC MODEL

The subsections of the section will be comparable to those in Section 3.2, with reference to the Mineralogy Model 3.1 (MM3.1) analysis (AP-3.10Q) report. The content of the subheadings provided in this section will be consistent with what was described for 3.2.

<Note: As noted in Sections 3.2 and 3.3, there may be fewer subheadings in the Construction and Results sections.>

3.4.1 Introduction

Section 3.4.1 introduces the 3D Mineralogic Model and illustrates the relationship between this component model and the other ISM components. It also describes the layout of the section.

3.4.2 MM3.1 Model Description

This section provides a description of the model consistent with the corresponding AP-3.10Q report, including its supporting codes, components, sub-models, and/or analysis.

3.4.3 Input Data and Qualification Status

This section summarizes the input data for construction of the 3D Mineralogic Model, and references the AP-3.10Q. The qualification status of these data is discussed, including methods used to qualify the data. The discussion also includes the qualification of software used to construct the model

3.4.4 Model Validation

This section is not applicable; see not in 3.2.4.

3.4.5 Construction of the Model

This section summarizes the methodology by which the model was constructed.

3.4.5.1 Stratigraphic Framework for the MM3.1

3.4.5.2 Modification of the GFM Files

3.4.5.3 Creation of the Borehole Model

3.4.5.4 Mineral Distributions

3.4.6 Model Results

This section provides the output of the model; this output is what serves as input to the end users (i.e., UZ or SZ flow and transport models).

3.4.6.1 Sorptive Zeolite Distribution

3.4.6.2 Smectite + Illite Distribution

3.4.6.3 Volcanic Glass Distribution

3.4.6.4 Silica Polymorph Distribution

3.4.7 Discussion of the MM3.1 Model Uncertainties and Limitations

This section discusses the uncertainties in the model and the assumptions and how they were derived. It also describes the approach taken to dealing with the uncertainties in the performance assessment (PA).

A brief discussion will also be provided regarding the results of verification exercises that were undertaken during the development of MM3.1. (Before their respective data were added to the model, elevation data for boreholes SD-6 and WT-24 were compared to the predicted results from the model to evaluate the estimated uncertainty window.)

<Note: In the "typical" PMR outline this section was positioned before Model Validation. It was moved to be after Results to be more consistent with the current ISM report.>

3.4.8 Data Qualification

This section demonstrates the qualification of any data necessary to support use of the model and its sub-models whose qualification has not been demonstrated in the previous sections. Summaries of, and cross-references to, discussions of data pedigrees in AP-3.10Q reports are also provided, as appropriate.

3.4.9 Alternative Interpretations

This section documents credible opposing views to the approaches and methods described in the PMR for the model under discussion. Depending on the best manner of addressing the subject as determined by the PMR authors,

The chapter or section consists of a relatively brief summary of the opposing view or position, accompanied by an explanation of why the Project does not subscribe to the opposing view or position. To the extent that compensatory measures have been or will be taken to deal with the opposing view, those measures are also described in this section.

The chapter or section also discusses findings of outside reviewers of the models and processes associated with the PMR, and it describes how the findings have been satisfactorily addressed.

Finally, the chapter or section discusses expert elicitation(s) applicable to the model and/or its abstraction, cross-referencing discussions in previous sections as appropriate.

CHAPTER 4 RELATIONSHIP WITH THE NUCLEAR REGULATORY COMMISSION (NRC) ISSUE RESOLUTION STATUS REPORTS

The NRC has indicated it plans to structure its review of issues within the PMRs with respect to the NRC's designated Key Technical Issues (KTIs) as described in the corresponding Issue Resolution Status Reports (IRSRs). Therefore, response to KTIs associated with ISM will be provided in this section

4.1 INTRODUCTION

This introduction summarizes the NRC's KTI and IRSR effort. The NRC staff has issued various IRSRs that describe the status of the KTIs from the NRC's perspective and provide subissues and acceptance criteria.

Review of the IRSRs, Revision 1, indicates that subissues associated with two KTIs are relevant to the ISM PMR. These are:

Structural Deformation and Seismicity
Unsaturated and Saturated Flow

These two KTIs will be described in the introduction. Subissues associated with these two KTIs are addressed in Sections 5.2 and 5.3, respectively.

<Note: The potentially applicable KTIs are currently under review and the topics addressed in this section could be modified accordingly.>

4.2 RELATIONSHIP OF ISM PMR TO STRUCTURAL DEFORMATION AND SEISMICITY KTI

This subsection (and the subsequent subsection) identifies a Key Technical Issue, its sub-issues, and associated acceptance criteria that are related to the PMR. The subsections discus how the PMR addresses the acceptance criteria for each sub-issue of the KTI. In many cases a given PMR only partially addresses a given KTI, and that fact is noted, as appropriate.

The sub-issues addressed under this KTI are listed in the following subsections. For each sub-issue, there will be a brief narrative describing the sub-issue and how it applies to the ISM. If it is believed that the sub-issue does *not* apply to the ISM, that will also be explained. Each applicable NRC criterion will then be stated in bullet format followed by a response to the comment.

4.2.1 Faulting

This section will be a brief narrative describing how faulting applies to the ISM. If it is believed that the sub-issue does *not* apply to the ISM, that will also be explained.

4.2.2 Seismicity

This section will be a brief narrative describing how seismicity applies to the ISM. If it is believed that the sub-issue does *not* apply to the ISM, that will also be explained.

4.2.3 Fracturing and Structural Framework of the Geologic Setting

This section will be a brief narrative describing how fracturing and the structural framework apply to the ISM. If it is believed that the sub-issue does *not* apply to the ISM, that will also be explained.

4.2.4 Tectonics and Crustal Conditions

This section will be a brief narrative describing how tectonics and crustal conditions applies to the ISM. If it is believed that the sub-issue does *not* apply to the ISM, that will also be explained.

4.3 RELATIONSHIP OF ISM PMR TO UNSATRUATED AND SATURATED FLOW UNDER ISOTHERMAL CONDITIONS KTI

This section will provide discussion of the subject KTI in a manner consistent with Section 5.2. The sub-issues addressed under this KTI are listed in the following subsections.

4.3.1 Present-Day Shallow Infiltration

This section will be a brief narrative describing how present-day shallow infiltration applies to the ISM. If it is believed that the sub-issue does *not* apply to the ISM, that will also be explained.

4.3.2 Saturated Zone Ambient Flow Conditions and Dilution Processes

This section will be a brief narrative describing a how saturated zone ambient flow conditions and dilution process applies to the ISM. If it is believed that the sub-issue does *not* apply to the ISM, that will also be explained.

REFERENCES

This chapter will contain the complete reference list for the document. Those that are considered as "directly relied upon" will be marked with an asterisk.

APPENDICES

The appendices will contain supporting information deemed appropriate for inclusion in the PMR but at too great a level of detail for the body of the report.

UNSATURATED ZONE FLOW AND TRANSPORT PROCESS MODEL REPORT

CHAPTER 1 INTRODUCTION

This chapter will provide "up front" information describing the purposes of the report, its basic organization, and related issues. This will also provide a high-level summary of how the UZ Flow and Transport (UZFT) PMR relates to technical topics presented in the other PMRs (and non-PMRs as appropriate), and key Project documents including topical reports, the Environmental Impact Statement (EIS), the Site Recommendation Report (SRR), and the License Application (LA).

1.1 OBJECTIVES

This section provides the objectives of the UZFT PMR (what its production is intended to accomplish). This will include the objective to compile in one place, as a stand-alone report, a synthesis of all the necessary and sufficient technical information, related to UZFT, that the Project will be relying upon to make its site suitability evaluation and ultimately the licensing argument pertaining to a particular process model. It will also include objectives common to all the PMRs.

1.2 SCOPE

This subsection explains the scope of the UZFT PMR. Flowcharts may be used to show the evolution of information from data to TSPA output. The general scope is as follows:

1.2.1 Scope of UZ Flow and Transport PMR

The UZ Flow and Transport PMR describes the processes affecting the amount of water entering the unsaturated zone above the repository and contacting wastes in the repository, and the movement of water with dissolved radionuclides or colloidal particles through the unsaturated zone below the repository. The purpose of the model is to describe the spatial and temporal distribution of water flow through the unsaturated zone and the spatial and temporal distribution of water seepage into the underground openings of the repository. The PMR also describes inputs from other PMRs and outputs from the UZ Flow and Transport model to the SZ Flow and Transport Model, EBS design and TSPA. The emphasis of the discussion of model inputs and outputs is on information needed for the assessment of postclosure performance.

1.2.2 Features, Events, and Processes (FEPs)

This subsection describes the approach used to include or exclude FEPs. It describes how FEPs were used to develop the models and submodels for UZ flow and transport. This subsection is supported by an Analysis and Model (AP-3.10Q) report.

1.2.3 Key Issues for UZ Flow and Transport

The subsection summarizes key issues that have been identified as part of the Peer Reviews of VA and the UZFT Model, Expert Elicitation, NRC IRSRs and KTIs, and from the UZ Model Workshop.

1.2.3.1 Summary of Key Issues from TSPA-VA

1.2.3.2 Summary of TSPA Peer Review Panel

1.2.3.3 Summary of Expert Elicitation

1.2.3.4 Summary of NRC IRSRs and KTIs

1.2.3.5 Summary of PA Workshop on UZ Flow and Transport (FY97 & FY99)

1.3 QUALITY ASSURANCE STATUS OF DATA AND SOFTWARE

This section explains the quality assurance controls under which the UZF&T PMR has been developed. The UZF&T PMR is expected to be designated as quality-affecting through QAP-2-0 analysis. As such the UZF&T PMR is developed under AP-3.11Q. The section also discusses the method through which non-Q data and references have been upgraded for incorporation in the UZF&T PMR via the constituent models and analyses developed in compliance with AP-3.10Q. In the case of the first version of the UZF&T PMR, discussions include how non-Q data referenced in the document are tracked with "TBVs." This section provides a general discussion, with the more specific demonstrations of compliance with quality assurance requirements to follow in later chapters and to be discussed in the referenced AP-3.10Q analyses.

1.3.1 Field Data (QA status)

Tables for the following field data will summarize their Q-status and provide traceability information including DTNs.

1.3.1.1 Infiltration/climate data

1.3.1.2 Matrix properties

1.3.1.3 Fracture properties

1.3.1.4 Pneumatic data

1.3.1.5 Saturation/Moisture tension data

1.3.1.6 Geochemical data

1.3.1.7 Temperature data

1.3.2 Developed Data (QA status)

Tables for the following parameter and data sets will summarize their Q-status and provide traceability information including DTNs.

1.3.2.1 Inverse models and parameter sets

1.3.2.2 Flow fields

1.3.2.3 Pre- and post-processed data

1.3.3 Software (QA status)

Tables for the following software will summarize their Q-status, SCMS ID, and version numbers.

1.3.3.1 ITOUGH2

1.3.3.2 TOUGH2

1.3.3.3 TOUGHREACT

1.3.3.4 EOS9nT

1.3.3.5 T2R3D

1.3.3.6 FEHM

1.4 RELATIONSHIP TO OTHER PROCESS MODEL REPORTS & KEY PROJECT DOCUMENTS

This section discusses how the UZFT PMR relates to the other PMRs in terms of interfaces and overlaps. It includes a list of all the PMRs and a summary-level purpose and description of each.

The section also explains how the UZFT PMR relates to documents such as the Yucca Mountain Site Description, the Natural Analogs report, the Natural Resources report, topical reports, the SRR, the LA, and other documents considered applicable.

1.5 OVERVIEW DESCRIPTION & RESULTS OF THE UZ FLOW AND TRANSPORT MODEL AND ABSTRACTION FOR TSPA-SR

This section provides a high-level description of the models, the abstractions of the models, the results of abstractions, and application of the models in the PMR. This section summarizes the information that is provided in more detail in Chapter 3 and in much greater detail in the reference AP-3.10Q analyses.

1.5.1 Overview of models of climate, infiltration, UZ flow & transport, seepage, and coupled processes

This section provides an overview of the models and submodels developed and utilized.

1.5.2 Results of UZ flow and transport models

This section provides a summary of the results presented in Section 3.

1.5.3 Results of abstractions for TSPA-SR

This section provides a summary of the results presented in Section 3.6.

1.5.4 Implications for performance

This section provides a summary of the results presented in Section 3.8.

CHAPTER 2 EVOLUTION OF THE UZ FLOW & TRANSPORT PMR

This chapter provides perspective on the background against which the UZFT PMR is being developed and describes its documentation structure. It provides a summary of 1) previous treatment of UZFT (background of previous modeling and abstraction), 2) current treatment of UZFT, 3) conceptual models used in the development of the models, submodels, and abstractions, and 4) the numerical approaches utilized to implement these conceptual models.

2.1 PREVIOUS TREATMENT OF UZ FLOW AND TRANSPORT (CITATIONS TO PREVIOUS NEPO AND PA REPORTS).

This section summarizes previous treatments of UZFT and references past NEPO and PA reports. It will also provide a discussion of the treatment of UZFT for VA.

2.2 SYNOPSIS OF CURRENT TREATMENT AND CHANGES FROM PREVIOUS EFFORTS

This section discusses the current treatment of UZFT and how it was changed from previous efforts. In particular any differences from VA will be discussed.

2.3 CONCEPTUAL MODELS FOR UZ FLOW AND TRANSPORT

The primary conceptual models for UZFT are discussed in this section. These include conceptual models of geology, UZ hydrology and transport, and site geochemistry.

2.3.1 Geology

This subsection provides a general discussion of the conceptual approach of incorporating GFM and ISM. In particular, a discussion on the approach to providing a distribution of vitric and zeolitic zones and their properties is provided.

2.3.1.1 Geologic Framework Model (GFM 3.1)

2.3.1.2 Mineralogical/Petrologic Model

2.3.1.3 Vitric/zeolitic distributions and properties

2.3.2 UZ Hydrology and Transport

This subsection provides a presentation of the basic conceptual models as it relates to the major components of flow and transport. Each of the components is addressed separately.

2.3.2.1 Climate

2.3.2.1 Infiltration

2.3.2.3 Fracture and Matrix components of flow & transport

2.3.2.4 Fracture/Matrix interaction

2.3.2.6 Effects of major faults

2.3.2.6 Transient flow

2.3.2.7 Flow focusing processes

2.3.2.8 Perched water

2.3.2.9 Effects of fracture and matrix heterogeneities

2.3.2.10 Seepage into drifts

2.3.2.11 Radionuclide transport processes

2.3.2.12 Gas flow processes

2.3.2.13 Effects of coupled processes (THMC)

2.3.3 Geochemical Conceptual Model

This subsection provides a discussion of the conceptual model for geochemistry incorporating the basic understanding of site geochemistry processes as supported by field data and observations.

2.3.3.1 Geochemical database

2.3.3.2 Geochemical properties (solubilities/sorption)

2.3.3.3 Measurement accuracy

2.3.3.4 Geochemical conceptual models

2.4 NUMERICAL APPROACHES FOR UZ FLOW AND TRANSPORT

This section discusses the numerical modeling approaches used to implement the conceptual models in Section 2.3.

2.4.1 Numerical Approaches for UZ Flow and Transport

The alternative numerical approaches are discussed and the basis for selecting certain approaches is presented.

2.4.1.1 Continuum approaches

2.4.1.2 Discrete fracture approach

2.4.1.3 Fracture network approach

2.4.1.4 Transport modeling including particle tracking

2.4.2 Description of Numerical Codes

The primary software codes used as part of the model and submodels for UZFT are presented in this subsection.

2.4.2.1 ITOUGH2

2.4.2.2 TOUGH2

2.4.2.3 TOUGHREACT

2.4.2.4 EOS9nT

2.4.2.5 T2R3D

2.4.2.6 FEHM

2.4.3 Grid Generation

This subsection discusses the development of the 3-D grid and the extraction and conversions of grid for use in modeling and abstractions. It references AP-3.10Q reports on these individual topics.

2.4.3.1 QA Status of Software and Data

2.4.3.2 Development of the 3-D Site-Scale Model Grid

2.4.3.3 Extraction of 1-D and 2-D Grids

2.4.3.4 Interface Between TOUGH2 and FEHM

CHAPTER 3 UZ FLOW & TRANSPORT MODEL AND ABSTRACTIONS

This chapter presents the models, submodels and data sets that are the principal components of UZFT and shows the relationship among the various components.

3.1 INTRODUCTION

This section gives an overview of the Chapter.

3.2 UZ MODEL PROPERTY SETS AND CALIBRATION MODELS

This section presents the individual models that feed the UZFT Model and the submodels that make up the overall UZFT Model. Each of these subsections is supported by one or more AP-3.10Q reports.

3.2.1 Available Data for UZ Flow and Transport

This subsection summarizes all the available field data incorporated into the models or utilized in model validation.

3.2.1.1 Boreholes (LBNL)

3.2.1.2 ESF (LBNL)

3.2.1.3 Field Studies

3.2.1.4 Natural Analogues (LBNL)

3.2.2 Hydrologic Properties for Site-Scale Model

This subsection presents initial estimates of hydrologic properties based on measurements and describes how final estimates of these properties are developed by calibration to field data. The calibration of the model on saturation, water potential, pneumatic, temperature, and geochemical data is discussed. This includes discussing the inverse-modeling techniques applied to iteratively adjust model parameters, forward calibration techniques for calibrations on temperature and geochemical data, and forward calibration techniques utilizing perched water models. This subsection is supported by several AP3.10Q reports.

3.2.2.1 Matrix property data

3.2.2.2 Fracture property data

3.2.1.3 Fault property data

3.2.1.4 Model Calibration

3.2.3 Hydrologic Properties for Drift-Scale Seepage Model

This subsection presents estimates of hydrologic properties based on calibrations to in-situ field data.

3.2.4 Transport Properties

This subsection presents estimates of transport properties based on laboratory measurements and field data.

3.2.4.1 Diffusion coefficients

3.2.4.2 Sorption parameters

3.2.4.3 Colloid transport parameters

3.3 UZ FLOW AND TRANSPORT SUBMODEL COMPONENTS

This section presents the individual models that feed the UZFT Model and the submodels that make up the overall UZFT Model. Each of these subsections is supported by one or more AP-3.10Q reports.

3.3.1 Climate Model (USGS)

This subsection summarizes the assumptions, approach, and results used in developing the Climate Model to evaluate potential future climatic changes for inputs into the Infiltration Model.

3.3.1.1 Introduction

3.3.1.2 Available data

3.3.1.3 Assumptions

3.3.1.4 Approach

3.3.1.5 Results for base-case

3.3.2 Infiltration Model (USGS)

This subsection summarizes the assumptions, approach, and results for the Infiltration Model used to develop the 1999 infiltration map used by the UZFT Model.

3.3.2.1 Introduction

3.3.2.2 Available data

3.3.2.3 Assumptions

3.3.2.4 Approach

3.3.2.5 Sensitivity Analyses

3.3.2.6 Analysis of Infiltration Uncertainties (PA)

3.3.2.7 Results for base-case

3.3.3 UZ Flow Model Components

This subsection presents the submodels of the UZFT Model. This includes models that simulate and investigate fracture/matrix interaction, the potential for flow focusing within the PTn hydrogeologic unit, the influence of faults with comparisons to field data, flow within the CHn hydrogeologic unit and the potential effect of zeolitic alteration on flow, and the perched water phenomena utilizing field data including locations of perched water and pumping testing data with comparisons to perched water residence times. Each of these submodels is supported by an AP-3.10Q report.

3.3.3.1 Fracture/Matrix Model (LBNL)

3.3.3.2 PTn Flow Model (LBNL)

3.3.3.3 Effects of Major Faults (LBNL)

3.3.3.4 Calico Hills Model (LBNL)

3.3.3.5 Perched Water Model (LBNL)

3.3.4 Model of Seepage into Drifts (LBNL)

This subsection presents the assumptions, approaches, results, and sensitivity analyses for seepage modeling on the drift-scale. This section is supported by several AP-3.10Q reports.

3.3.4.1 Introduction

3.3.4.2 QA

3.3.4.3 Model domain

3.3.4.4 Available field data

3.3.4.5 Conceptual models

3.3.4.6 Field testing

3.3.4.7 Numerical Model

3.3.4.8 Sensitivity analyses

3.3.4.9 Summary

3.3.5 UZ Transport Model Components (LBNL, LANL, PA)

This subsection presents the model components for modeling transport. It includes assumptions, approaches, results, and sensitivity analyses. It is supported by several AP-3.10Q reports.

3.3.5.1 Introduction

3.3.5.2 QA

3.3.5.3 Model domain

3.3.5.4 Available field data

3.3.5.5 Conceptual models

3.3.5.6 Field testing

3.3.5.7 Numerical Model (LBNL, LANL, PA)

3.3.5.8 Sensitivity analyses

3.3.5.9 Summary

3.3.6 Coupled Processes Model (LBNL, PA)

This subsection discusses coupled process models for the drift-scale and the mountain-scale. The assumptions, approaches and incorporation of these coupled processes into models are also discussed. The models discussed simulate reaction-transport processes for non-isothermal multicomponent, multiphase, and multispecies systems. Changes in flow and transport due to changes in permeability, porosity, and unsaturated flow parameters as a function of rock-water interaction are evaluated on different scales. This subsection is supported by AP-3.10Q reports for individual coupled process models.

3.3.6.1 Introduction

3.3.6.2 QA

3.3.6.3 Model domain

3.3.6.4 Available field data

3.3.6.5 Conceptual models

3.3.6.6 Numerical Model

3.3.6.7 Durable Property Changes

3.3.6.8 Incorporation into UZ Flow and Transport Model

3.3.6.9 Incorporation into Drift-Scale Seepage Model

3.3.6.10 Sensitivity analyses

3.3.6.11 Summary

3.4 INTEGRATED UZ FLOW AND TRANSPORT MODEL FOR TSPA-SR (LBNL)

This section presents the integrated model, including all assumptions, abstractions, and uncertainties.

3.4.1 QA Status of data and computer software

This subsection lists the data, model output, and software used to develop the integrated flow and transport model. It also lists the quality status and provides traceability information including data tracking numbers.

3.4.2 Available data and incorporation in model calibration studies

This subsection provides a summary list of the available data and how it was used to calibrate the model. Computations performed to compile data are also discussed.

3.4.3 Description of the integrated UZ flow model

A summary description of the integrated model is provided here. This includes conceptual models used in its development and references to AP3.10Q reports regarding conceptual model development.

3.4.4 Assumptions

The assumptions used in the development of the integrated model are provided here. Also any caveats, constraints, and limitations of the model are discussed.

3.4.5 Multi-dimensional model calibration with borehole saturation and water potential data

This subsection presents the results of multi-dimensional calibrations on borehole data. This includes 2-D inversions for lower layers (below Topopah Springs) and faults and 3-D forward calibrations on observations including saturations, water potentials, and pressures. The effect of multi-dimensional calibrations on model parameters is also evaluated.

3.4.6 3-D, dual-k, perched water model

This subsection discusses the full integration of the model including the dual-k approach and perched water model. Results are presented for selected scenarios and percolation flux and breakthrough curves at the water table are presented. This section also discusses groundwater travel time from the repository horizon to the water table.

3.4.7 Uncertainties and recommendation for additional data collection and modeling

This subsection discusses the overall uncertainties in the integrated model. It identifies the areas and issues of most concern and provides recommendations of additional data collection and modeling to reduce these uncertainties.

3.5 UZ FLOW AND TRANSPORT MODEL VALIDATION

This section provides documentation for demonstrating the validity of the model per Quality Assurance Requirements and Description (DOE/RW-0333P) Glossary and AP-3.10Q. Results of expert elicitation used to support model validation are included. The discussion summarizes use of natural and man-made analogues in the model validation.

3.6 ABSTRACTIONS AND RESULTS FOR TSPA-SR

This section describes the method of abstracting the UZFT model into the TSPA. Results of expert elicitation and abstraction workshops are also included. Discussions include any assumptions needed to support the abstraction and descriptions of the approach taken to deal with the uncertainties in the model abstraction process.

3.6.1 Base-Case Analyses, Results, and Abstractions for TSPA-SR

This subsection presents the abstractions and results for the base-case. Flux and cumulative breakthrough curves at the water table are provided and evaluated to provide insight into subsystem performance for the unsaturated zone. It is supported by an AP-3.10Q report. Groundwater travel times from the potential repository horizon to the water table are discussed in subsection 3.6.1.4.3.

3.6.1.1 Define base-case runs (PA)

3.6.1.2 Site-Scale UZ Flow

3.6.1.3 Seepage into Drifts

3.6.1.4 Site-Scale UZ Transport (PA)

3.6.2 Sensitivity Analyses, Results, and Abstractions for TSPA-SR

This subsection presents the sensitivity analyses performed. For site-scale UZ Flow, This includes analysis of the effects of altered property sets, different climate and infiltration ranges, longer time frames, variations of parameter sets, and alternative conceptual models. It is supported by an AP-3.10Q report.

3.6.2.1 Site-Scale UZ Flow (LBNL, PA)

3.6.2.2 Seepage into Drifts (LBNL, PA)

3.6.2.3 Site-Scale UZ Transport (PA)

3.6.3 Validation of Abstractions

This section contains a demonstration of the validity of the abstractions. Results of peer reviews or other evaluations of the model abstraction process are included. The discussion summarizes use of natural and man-made analogues in validating the abstraction as appropriate.

3.7 DATA QUALIFICATION

This section demonstrates the qualification of any previously non-qualified data needed to support the use of the model and its sub-models.

3.8 SUMMARY OF IMPACT ON PERFORMANCE

This section discusses the results of each of the major components and their impact on performance. It also discusses uncertainties, assumptions, and limitations.

3.8.1 Climate

This subsection discusses the effect of different climate model assumptions on the overall performance.

3.8.2 Infiltration

The range of infiltration rates and the assumptions regarding surface runoff and channeling are discussed in terms of the resulting effect on performance.

3.8.3 UZ Flow

This subsection discusses the important findings relating to flow in the unsaturated zone and which components of flow and key assumptions in flow conceptual models have the greatest impact on performance.

3.8.4 Seepage

Seepage into drifts and the impact of conceptual models and ranges of parameters utilized is discussed. Its impact is evaluated in the context of performance of the entire natural system.

3.8.5 UZ Transport

This subsection discusses the effect of the key assumptions relating to transport properties and conceptual models on performance. The uncertainties in the modeling of UZ transport are also discussed in terms of the resulting potential impact on performance.

3.8.6 Coupled Processes

The importance of coupled processes and durable changes in rock properties are discussed. This includes thermal and mechanical processes at the drift and mountain scale. The overall impact is evaluated in terms of its effect on transport relative to transport under ambient conditions.

3.8.6.1 UZ Flow

3.8.6.2 Drift-Scale Seepage

3.8.6.3 UZ Transport

3.9 SUMMARY OF OTHER VIEWS & ALTERNATIVE CONCEPTUAL MODELS

This section documents credible opposing views to the approaches and methods utilized for UZFT and alternative conceptual models. The section consists of a relatively brief summary of the opposing view or position, accompanied by an explanation of why the Project does not subscribe to the opposing view or position.

CHAPTER 4 RELATIONSHIP WITH NRC IRSR

This chapter presents the NRC's designated Key Technical Issues (KTI) and Issue Resolution Status Reports (IRSR) and how these have been addressed in the PMR.

4.1 SUMMARY OF KTI'S AND IRSR'S

This section summarizes the NRC's KTI and IRSR effort.

4.2 RELATIONSHIP OF PMR TO KTI'S

This section of the PMR describes how each KTI and its constituent subissues and acceptance criteria have been addressed through the PMR. Each of the subsections identifies a Key Technical Issue, its subissues, and associated acceptance criteria that are related to the PMR. The subsections discuss how the PMR addresses the acceptance criteria identified for each subissue of each KTI.

REFERENCES

Complete references including accession numbers are included here.

APPENDIX A: UZ FLOW AND TRANSPORT ISSUES WHITE PAPER

APPENDIX B: UZ TRANSPORT/AN OPINION

SATURATED-ZONE FLOW AND TRANSPORT MODEL PROCESS MODEL REPORT

CHAPTER 1.0 INTRODUCTION

This chapter provides the "up front" information necessary for the reader to understand the purposes of the report, its basic organization, and related issues. It also supports the reader who desires a quick look at the document without reviewing it in great detail. This chapter provides a high-level summary of how the Saturated Zone (SZ) Flow and Transport Process Model (PMR) relates to technical topics presented in the other PMRs (and non-PMRs as appropriate), and key Project documents including topical reports, the Environmental Impact Statement (EIS), the Site Recommendation Report (SRR), and the License Application (LA).

1.0 INTRODUCTION

Section 1.0 contains introductory text that briefly describes the goal of the Yucca Mountain Project, which is to determine suitability of the Yucca Mountain site for disposal of high-level nuclear waste. If the site is found suitable, the goal is to then seek a license to construct and subsequently to operate and eventually close a high-level waste disposal facility. It goes on to briefly describe the role of the SZ PMR in meeting those goals. Finally, the section summarizes the layout of the SZ PMR.

1.1 OBJECTIVE

This section provides the objectives of the SZ PMR Briefly, the main objective is to compile a stand-alone report that is a synthesis of all the necessary and sufficient technical information related to the saturated zone that the Project will be relying upon to make its site suitability evaluation. Also much of this information may be used in a license application. The technical information consists of data, analyses, models, software and supporting documents used to develop the SZ PMR model and defend the applicability of the model to evaluate postclosure performance of the Yucca Mountain repository. The SZ PMR serves as an important reference for Total System Performance Assessment (TSPA) and key program milestone documents (EIS, SRR, and LA) and is written for a readership of knowledgeable persons in technical and regulatory fields.

1.2 SCOPE

This section explains the information presented in and the content of the SZ PMR. It uses flowcharts to show the evolution of information from data to TSPA output and the evolution of information within the SZ the PMR. The section also describes where to find relevant subject matter not included in the SZ PMR. References to related discussions in Chapter 2 are provided.

The SZ Flow and Transport PMR describes the processes that control the movement of water with dissolved radionuclides or colloidal particles through the saturated zone below the repository and produce reductions in radionuclide concentrations in the saturated zone. The purpose of the model is to describe the spatial and temporal distribution of water flow through the saturated zone to the point of uptake by the critical exposure group. The PMR also describes inputs from other PMRs and outputs from the model to the Biosphere PMR and TSPA. The discussion of model inputs and outputs is on information needed for the assessment of postclosure performance.

1.3 QUALITY ASSURANCE

This section explains the quality assurance controls under which the SZ PMR has been developed. The PMR is expected to be designated as quality-affecting through QAP-2-0 analysis. As such the SZ PMR is developed under AP-3.11Q. The section also discusses the method through which non-Q data and references have been upgraded for incorporation in the PMR via the constituent models and analyses developed in compliance with AP-3.10Q. In the case of the first version of the PMR, discussions include how non-Q data referenced in the document are tracked with "TBVs." This section provides a general discussion, with the more specific demonstrations of compliance with quality assurance requirements to follow in later chapters and to be discussed in the referenced AP-3.10Q analyses.

1.4 RELATIONSHIP TO OTHER PROCESS MODEL REPORTS AND KEY PROJECT DOCUMENTS

This section discusses how the SZ PMR relates to the others in terms of interfaces and overlaps. It includes a list of all the PMRs and a summary-level purpose and description of each. The section explains how this PMR relates to documents such as the Yucca Mountain Site Description, the Natural Analogs report, the Natural Resources report, topical reports, the SRR, the LA, and other applicable and appropriate documents. It also describes the relationship between the subject matter of this PMR and other contributory or subsequent process models. This discussion may overlap with some of the information under Section 1.2, "Scope" above.

1.4.1 Integrated Site Model PMR

The Integrated Site Model (ISM) PMR describes the framework for discussing the geologic properties of the site (e.g., stratigraphy, structural characteristics, and rock properties) that is provided by the ISM. The ISM PMR describes how geophysical and hydrologic properties information has been used to characterize the geologic properties of the site. The report also describes how the output from the ISM is used as input to the unsaturated zone (UZ) flow and transport model, the saturated zone flow and transport model, tectonic hazards, and Engineered Barrier System design. The Saturated Zone Flow and Transport Process Model Report will use geologic properties information developed and documented in the ISM PMR to establish the baseline site framework.

This section describes how the geologic material properties in the ISM model were utilized in the SZ flow and transport model component of the TSPA. Material properties in the ISM that will be used in the SZ site-scale model include matrix porosity and bulk density

1.4.2 Unsaturated Zone Flow and Transport PMR

The Unsaturated Zone Flow and Transport Process Model Report describes the processes affecting the amount of water entering and flowing through the unsaturated zone above the repository, contacting wastes in the repository, and the movement of water with dissolved radionuclides or colloidal particles through the unsaturated zone below the repository. The purpose of the model is to describe the spatial and temporal distribution of water flow through the unsaturated zone and the spatial and temporal distribution of water seepage into the underground openings of the repository. The PMR also describes inputs from other PMRs and outputs from the Unsaturated Zone Flow and Transport model to the Saturated Zone Flow and Transport Model, Engineered Barrier System design and Total System Performance Assessment. The emphasis of the discussion of model inputs and outputs is on information needed for the assessment of postclosure performance. The Saturated Zone Flow and Transport Model will receive inputs of spatial and temporal distribution of recharge and radionuclide transport from the Unsaturated Zone and Transport Model.

This section describes the interface between the UZ site-scale model and the SZ site-scale model, both in terms of groundwater flow and in terms of radionuclide transport. Recharge boundary conditions for the SZ model will be specified based on the groundwater flux simulated at the base of the UZ model. Coupling of the radionuclide transport between the UZ and the SZ will be accomplished with the convolution integral method.

1.4.3 Biosphere PMR

The Biosphere Process Model Report addresses the characteristics that describe the lifestyle and habits of individuals who potentially could be exposed to radioactive material at some time during the postclosure performance period. The Biosphere PMR describes the reference biosphere and the characteristics of the critical group including pathways, location and behavior representative of current conditions, and biosphere transport and uptake. The Biosphere Process Model Report will receive information feeds from the Saturated Zone Flow and Transport Model of amount of groundwater flow from the Yucca Mountain site and the spatial and temporal distribution of radionuclides transported.

This section will describe the conceptual model and regulatory basis for the coupling of the radionuclides at the 20 km boundary in the SZ and the biosphere model.

1.5 OVERVIEW DESCRIPTION AND RESULTS OF MODELS AND ABSTRACTION

This section provides a high-level description of the SZ model, the abstractions of the model, the results of abstractions, and application of the models in the PMR. This section basically summarizes the information that is provided in more detail in Chapter 3 and in much greater detail in the reference AP-3.10Q analyses. The section also contains a summary of Chapter 4 that integrates all the PMR models, abstractions, and analyses. The section is intended to support the reader who wants to get the gist of the report without examining it in great detail.

CHAPTER 2.0 EVOLUTION OF THE SZ PROCESS MODEL

This chapter provides perspective on the background information from which the PMR is being developed and describes the overall documentation structure of which the PMR is a part.

Next, the chapter provides a summary of previous treatment of the SZ (background of previous modeling and abstraction).

The chapter then summarizes the development of the SZ process model and abstractions and describes the conceptual approach. It provides references to sections of Chapter 3 that contain the descriptions of the technical details associated with the development of the SZ process models and abstractions.

2.1 OVERVIEW AND DEVELOPMENT APPROACH

This section will explain the philosophy for developing the PMRs, and why the SZ PMR is being developed.

2.2 SZ BASELINE

This section will discuss how the SZ baseline was established. This will include discussion on the hydrogeologic baseline, water level, geochemistry, and transport parameters.

2.3 PREVIOUS SZ MODELING

This chapter provides information on previous modeling developed at various scales to simulate groundwater flow and transport in the vicinity of Yucca Mountain. Implications of the present SZ methodology relative to previous approaches will be discussed.

2.4 PREVIOUS TSPA MODELING

This section will summarize how the transport of radionuclides in the SZ has been handled in previous TSPA analyses. Implications of the present SZ methodology relative to previous approaches will be discussed.

2.5 RELATIONSHIP OF SZ PMR TO SUPPORTING ANALYSIS DOCUMENT

The discussion includes a description of the relationship among the SZ PMR and the constituent sub-process models, abstraction models, and analyses (as applicable) developed under AP 3.10Q procedure. Whereas section 1.2 uses a flowchart to describe the information flow associated with the subject of the PMR, this chapter discusses the same subject, but in terms of the document structure (AP-3.10Q analysis packages, the PMR itself, and other documents as applicable).

CHAPTER 3.0 SATURATED-ZONE FLOW AND TRANSPORT MODEL AND ABSTRACTIONS FOR TSPA-SR

Chapter 3 describes the SZ site-scale flow and transport model, abstractions, and analyses. Discussions will include the relationships among the models, abstractions, data, and analyses.

3.0 INTRODUCTION

Section 3.0 identifies and introduces the models that are the principal subject of the chapter and shows the relationship among the various components that are discussed in the chapter. The bases for the scopes of the models (number of processes and/or sub-models included) are explained in terms of the conceptual models that provide the bases for the process models. This section also describes the layout of the chapter discussion of those components.

Sections 3.1 through 3.4 provide primary descriptions of the SZ model components. The SZ process model and other models will feed the SZ abstracted models.

3.1 SATURATED ZONE FLOW AND TRANSPORT CHARACTERIZATION

Section 3.1 describes the SZ system at the regional and site scales. It summarizes the geologic, hydrologic, hydrochemical, and transport data.

3.1.1 Description of the SZ System

This section presents the regional and site scale setting for the SZ system including geology, hydrology and hydrochemistry.

3.1.1.1 Regional Flow System

3.1.1.1.1 Geologic Setting

3.1.1.1.2 Hydrologic Setting

3.1.1.1.3 Hydrochemistry

3.1.1.2 Site-Scale Flow System

3.1.1.2.1 Geologic Setting

3.1.1.2.2 Hydrologic Setting

3.1.1.2.3 Hydrochemistry

3.1.2 Summary of Hydrologic Data

This section will summarize the hydrologic data including water level data, hydraulic well testing data including the C-well testing. It will also summarize the recharge and infiltration studies.

3.1.2.1 Water Level Measurements

3.1.2.2 Hydraulic Well Tests

3.1.2.3 Infiltration and Recharge

3.1.3 Summary of Hydrochemical Data

This section will summarize all the hydrochemical data and tests including tracer tests and oxidation potential.

3.1.3.1 Spatial Patterns of Groundwater Chemistry

3.1.3.2 Tracer Tests

3.1.3.3 Oxidation Potential

3.1.4 Summary of Laboratory Data

This section will summarize the laboratory and experiment data used in the SZ flow and transport model including sorption, matrix diffusion, and colloid facilitated transport experiments.

3.1.4.1 Sorption Experiments

3.1.4.2 Matrix Diffusion Experiments

3.1.4.3 Colloid-Facilitated Transport Experiments

3.2 CONCEPTUAL MODEL OF THE SATURATED ZONE SITE-SCALE FLOW AND TRANSPORT SYSTEM

This section will describe the SZ site-scale flow and transport conceptual model that form the basis of the numerical model of SZ flow and transport in the site-scale model. This will include the hydrogeologic framework model, the boundary conditions used in the model, contaminant transport processes considered at Yucca Mountain, other alternative conceptual models, and climate changes. When possible, justification for the various components of the conceptual model will be made by referring to observations at the Yucca Mountain site.

3.2.1 Hydrogeologic Framework

The hydrogeologic Framework model will identify the different units used in the model and their properties. It will describe the hydrologic features, the role of faults in flow and transport. It will discuss the conceptual relationship between the geologic setting and the distribution of hydrologic properties in the SZ site-scale flow and transport model. Justification of the conceptual model will be documented in this section

3.2.1.1 Hydrogeologic Units

3.2.1.2.1 Hydrologic Features

3.2.1.2.2 Role of Faults

3.2.1.2.3 Heterogeneity

3.2.1.2.4 Large, Moderate, and Low Hydraulic Gradients

3.2.2 Boundary Conditions

This section will discuss the conceptual basis and assumptions associated with the boundary conditions used in the SZ site-scale flow model. The relationship with the regional groundwater flow system will be discussed. Recharge to and discharge from the model will be discussed.

3.2.2.1 Lateral Boundaries

3.2.2.2 Recharge

3.2.2.3 Discharge

3.2.3 Solute Transport Processes

The conceptual basis and assumptions in the radionuclide transport model for the SZ site-scale model will be discussed in this section. Justification for the representation of these processes in the model will be presented. Discussions in this section (or an appropriate subsection) will include a description of the average groundwater travel time from the water table below the potential repository to the compliance point. Discussions in this section will include information about groundwater travel time between the repository horizon and the water table that will be provided in Sections 3.4.6 and 3.6.1.4.3 of the UZ PMR so that the discussion will summarize average groundwater travel time between the repository horizon and the compliance point.

3.2.3.1 Advection

3.2.3.2 Matrix Diffusion

3.2.3.3 Sorption

3.2.3.4 Hydrodynamic Dispersion

3.2.3.5 Colloid-Facilitated Transport

3.2.4 Alternative Conceptual Models

This section will present the alternative conceptual models of the SZ flow system that have been considered in the SZ site-scale flow model. Potential implications for repository performance will be discussed.

3.2.4.1 Large Hydraulic Gradient

3.2.4.2 Perched Water Table

3.2.5 Climate Change

The conceptualization of climate change processes and their impact on the SZ flow system will be presented in this section. Consistency with other components of the TSPA analysis will also be discussed.

3.2.5.1 Changes in Water Table Elevation

3.2.5.2 Changes in the SZ Flow System

3.2.5.2.1 Groundwater Flux

3.2.5.2.2 Recharge and Discharge

3.3 MATHEMATICAL AND NUMERICAL MODELING APPROACH

This section will describe the implementation of the conceptual model of SZ flow and transport into the numerical model.

3.3.1 Mathematical Model of Groundwater Flow

The equations of groundwater flow, as used by the SZ site-scale model in the FEHM computer code, will be presented in this section. Relationship of this mathematical representation to the conceptual model will be documented.

3.3.2 Mathematical Model of Radionuclide Transport

The equations of radionuclide transport in groundwater, as used by the SZ site-scale model in the FEHM computer code, will be presented in this section. Relationship of this mathematical representation to the conceptual model will be documented.

3.3.2.1 Advection-Dispersion

3.3.2.2 Matrix Diffusion

3.3.2.3 Sorption

3.3.2.4 Hydrodynamic Dispersion

3.3.2.5 Colloid-Facilitated Transport

3.3.3 Numerical Implementation of Groundwater Flow Equations in FEHM

This section will document the numerical solution methods used in FEHM to solve the groundwater flow equations

3.3.4 Particle Tracking Method for Radionuclide Transport in FEHM

This section will document the numerical solution methods used in FEHM to solve the radionuclide transport equations. This will cover the advection component, the random walk algorithm used to solve for dispersion, and the sorption and matrix-diffusion sub-models.

3.3.4.1 Random-Walk Algorithm

3.3.4.2 Sorption and Matrix-Diffusion Sub-models

3.3.5 Hydrogeologic Framework Model

This section will describe the representation of the geology in the grid of the SZ site-scale model. Implications of the resolution of the geology in the grid will be discussed.

3.3.6 Grid Generation

The design and geometry of the numerical grid will be discussed in this section. Justification for the grid geometry will be presented

3.3.7 Flow-Model Construction

This section will describe the interrelationship among the components of the numerical model. The relationship to the grid generation will be discussed.

3.3.8 Heterogeneity and Geostatistical Simulation

This section will document the results of sub-grid block modeling of heterogeneity and the resulting conclusions regarding dispersion in radionuclide transport.

3.3.9 Regional-Scale Flow Modeling

This section will describe the implementation of results from the SZ regional-scale flow model in the SZ site-scale flow model.

3.3.9.1 Groundwater Flux at Site-Scale Model Boundaries

3.3.9.2 Response to Climate Change

3.4 MODEL VALIDATION ACTIVITIES

This section will describe the model validation activities including calibration to water level, calibration to hydrochemical observations, calibration to pump tests at the C-wells. The use of natural analogues in calibration and validation will be discussed. Uncertainty in the process model will also be discussed in this section.

3.4.1 Calibration to Water Levels

This section will describe the results of calibration efforts using optimization methods to obtain best fit to hydraulic-head (water level) data. A number of conceptual models will be evaluated using regression methods.

3.4.1.1 Model Inversion Methodology

3.4.1.2 Calibration Results

3.4.2 Calibration to Hydrochemical Observations

This section will document how geochemical and isotopic data and analysis is used to constrain rates and directions of ground-water flow near Yucca Mountain and the timing and magnitude of recharge in the Yucca Mountain vicinity.

3.4.3 Calibration to Pump Tests at the C-Wells

This subheading will summarize the calibration process of the SZ model to the C-Wells hydraulic testing.

3.4.4 Natural Analogues

This chapter will summarize the data from natural analogue sites relevant to SZ flow and transport processes. The analysis will include a literature review of existing studies (from the international community and the U.S.), including retardation in saturated alluvium, dispersion and dilution in contaminant plumes, colloid transport, and other radionuclide transport in the SZ. Modeling simulations are presented for use of Hanford data on transport of tritium in saturated alluvium as a test of modeling dispersion in the SZ flow and transport model. Recommendations are made for application of SZ process analogues to PA and possibly to design.

3.4.5 Process Model Uncertainty

This section will discuss uncertainty in the model parameters used. It will discuss uncertainty in the processes simulated in the model. Results of sensitivity analysis will be discussed.

3.5 ASSUMPTIONS, USES AND LIMITATIONS OF THE SATURATED ZONE SITE-SCALE MODEL

This section will describe the different assumptions made in the flow and transport model. The discussion will cover the use and limitation of the site-scale flow and transport model.

3.5.1 Groundwater Flow Processes

This subheading will discuss the assumptions and limitations associated with groundwater flow processes.

3.5.2 Radionuclide Transport Processes

This subheading will discuss the assumptions and limitations associated with radionuclide transport processes.

3.5.3 Uses in Site Characterization Activities

This section will discuss the SZ site-scale flow and transport model in site characterization activities.

3.5.4 Modeling Limitations

This section will list all modeling limitations including the non-uniqueness in the solution and calibration and other limitation in data and representation of processes.

3.6 SYNTHESIS OF SZ MODEL AND MODEL ABSTRACTIONS

This chapter synthesizes the information from the various PMRs into a coherent discussion of how the Saturated Zone is satisfactorily addressed.

3.6.1 Introduction

The chapter begins with an introduction that briefly describes why a synthesis of related information in the various process models is needed. Cross-references are made to the locations in other PMRs where models, abstractions, and analyses related to the SZ are discussed in more detail.

3.6.2 Results of Synthesis

This section provides a detailed description of how the component parts (models, abstractions, and analyses) of the Project's approach to addressing the process are used together to predict the effect of each process on repository performance. This section focuses on the technical description that shows the process is addressed with acceptable levels of uncertainty. Some aspects of showing the validity of the overall method may need to be captured in subsections.

3.6.3 Analysis Approach To Saturated Zone Flow And Transport For Total Systems Performance Assessment Analyses

This sub-heading will document the incorporation of the SZ site-scale flow and transport modeling results into the TSPA analyses.

3.6.3.1 General Approach

An overview of the structure of the TSPA calculations will be presented in this section

3.6.3.2 TSPA Three-Dimensional Flow and Transport Model

This section will discuss the specific SZ flow and transport calculations performed with the SZ site-scale model for TSPA.

3.6.3.3 Abstraction of Radionuclide Transport

This section will describe the simplifications of the SZ site-scale model implemented for incorporation into TSPA analyses. The conceptual basis and justification for these abstractions will be discussed

3.6.3.3.1 Convolution Integral Method

3.6.3.3.2 Alternative Climate States

3.6.3.3.3 Assumptions

3.6.3.3.4 Dilution in Water Supply

3.6.3.4 Coupling of SZ Flow and Transport with Other Components of TSPA Analyses

This section will describe the details of the coupling between SZ flow and transport with UZ transport and the biosphere components of TSPA.

3.6.3.4.1 Unsaturated-Zone Flow and Transport

3.6.3.4.2 Biosphere

3.6.3.4.3 Implementation with the RIP Computer Code

3.7 SATURATED ZONE FLOW AND TRANSPORT BASE CASE

This sub-heading will document the set of probabilistic analyses for SZ flow and transport that constitute the base case for TSPA.

3.7.1 Description of the Base Case

This section will summarize those FEPs for SZ flow and transport that are explicitly or implicitly included in the base case.

3.7.1.1 Features, Events, and Processes Considered

3.7.1.2 Uncertainty

3.7.2 Parameter Uncertainty Distributions

The uncertainty distributions for stochastic parameters used in the base case will be presented in this section. A summary of the basis for uncertainty distributions will be documented.

3.7.3 Probabilistic Analyses

This section will describe those aspects of the analysis of SZ flow and transport that are handled probabilistically in the TSPA.

3.7.4 Results

The base case results (i.e., the SZ unit breakthrough curves at 20 km distance) will be presented in this section.

3.7.5 Interpretations

This section will include a discussion of the base case results. Implications for repository performance calculations will be examined.

3.8 DATA QUALIFICATION

This section demonstrates the qualification of any data necessary to support use of the model and its sub-models whose qualification has not been demonstrated in the previous sections. Summaries of, and cross-references to, discussions of data pedigrees in AP-3.10Q reports are also provided, as appropriate.

3.9 SUMMARY OF OTHER VIEWS & ALTERNATIVE CONCEPTUAL MODELS

This section discusses the review comments and criticisms resulting from the PA Peer Review of TSPA-VA. A description of how these issues were addressed in the TSPA will be provided. Discussions will also include how the major issues identified in the SZ expert elicitation were handled in the SZ site-scale flow and transport model and in TSPA analyses. Issues regarding SZ flow and transport processes raised in the FY99 SZ workshop will be summarized in this section.

CHAPTER 4.0 RELATIONSHIP WITH THE NUCLEAR REGULATORY COMMISSION (NRC) ISSUE RESOLUTION STATUS REPORTS

Because the NRC has indicated it plans to structure its review of issues that are subjects of PMRs around the NRC's designated Key Technical Issues (KTI) and Issue Resolution Status Reports (IRSR), this chapter of the SZ PMR describes how the acceptance criteria in the IRSRs have been addressed.

4.1 INTRODUCTION

This introductory subsection summarizes the NRC's KTI and IRSR effort. The NRC has determined that resolution of its designated KTIs is crucial to licensing the repository. The NRC staff has issued various IRSRs that describe the status of the KTIs from the NRC's perspective and provide subissues and acceptance criteria. Some of the KTIs may correspond to, or overlap with, the issues and processes that the PMR addresses. This section of the PMR describes how each KTI and its constituent subissues and acceptance criteria have been addressed through the PMR.

Each subsection that follows identifies a Key Technical Issue, its subissues, and associated acceptance criteria that are related to the PMR. The subsections discuss how the PMR addresses the acceptance criteria identified for each subissue of each KTI. In many cases a given PMR only partially addresses a given KTI, and that fact is noted as appropriate.

4.2 NRC IRSRS AND KTIS

This section identifies a Key Technical Issue, its subissues, and associated acceptance criteria that are related to the PMR. The section discusses how the PMR addresses the acceptance criteria identified for each subissue of each KTI. In many cases a given PMR only partially addresses a given KTI, and that fact is noted as appropriate.

The discussions include how key issues and uncertainties identified in TSPA-VA were addressed in the present modeling of SZ flow and transport.

REFERENCES

This chapter contains the complete reference list for the document.

APPENDICES

The appendices contain supporting information deemed appropriate for inclusion in the PMR (if any) but at too great a level of detail for the body of the report.

NEAR-FIELD ENVIRONMENT PROCESS MODEL REPORT (PMR)

CHAPTER 1.0 INTRODUCTION

This chapter provides the "up front" information necessary for the reader to understand the purposes of the report, its basic organization, and related issues. It also supports the reader who desires a quick look at the document without reviewing it in detail. This chapter also provides a high-level summary of how the Near-Field Environment (NFE) PMR relates to technical topics presented in the other PMRs (and non-PMRs as appropriate), and key Project documents including topical reports, the Environmental Impact Statement (EIS), the Site Recommendation Report (SRR), and the License Application (LA).

1.0 INTRODUCTION

Section 1.0 contains introductory text that briefly describes the goal of the Yucca Mountain Project, which is to determine suitability of the Yucca Mountain site for disposal of high-level nuclear waste. If the site is found suitable, the goal is to then seek a license to construct and subsequently to operate and eventually close a high-level waste disposal facility. It goes on to briefly describe the role of the PMR in meeting those goals. Finally, the section summarizes the layout of the PMR.

1.1 OBJECTIVE

This section provides the objective (or objectives) of the NFE PMR (what its production is intended to accomplish). Briefly, the objective is to compile in one place, as a stand-alone report, a synthesis of all the necessary and sufficient technical information, related to the near-field environment, that the Project will be relying upon to make its site suitability evaluation and ultimately the licensing argument pertaining to a particular process model. The technical information consists of data, analyses, models, software and supporting documents used to develop the PMR model (or models) and defend the applicability of the model for its intended purpose. The PMR serves as an important reference for Total System Performance Assessment (TSPA) and key Program milestone documents (EIS, SRR, and LA) and is written for a readership of knowledgeable persons in technical and regulatory fields. Many of the objectives are common to all the PMRs, though one or more may also be specific to a given PMR.

1.2 SCOPE

This section explains the information presented in and the content of the PMR. It uses one or more flowcharts to show the evolution of information from data to TSPA output, showing in the flowcharts what parts of the evolution are included in the PMR. The section also describes where to find relevant subject matter not included in the PMR. References to related discussions in Chapter 2 are provided.

In summary, the NFE PMR will describe processes important to limiting the amount of water that could contact waste. Processes include the effects of heat from the waste on water flow through the unsaturated zone at the emplacement drift wall, temperature and humidity (thermodynamic environment) in the engineered barriers, and the chemical reactions and products and mechanical interactions in the near-field host rock surrounding the emplacement drifts. In-drift water chemistry and gas compositions are also described. The PMR also will describe inputs from other PMRs and outputs from the model to the UZ Flow and Transport model, EBS design, and TSPA. The emphasis of the discussion of model inputs and outputs is on information needed for the assessment of postclosure performance.

1.3 QUALITY ASSURANCE

This section provides a general discussion of the quality assurance controls under which the PMR has been developed. The PMR is expected to be designated as quality affecting through QAP-2-0 analysis. As such the PMR is developed under AP-3.11Q. The section also discusses the method through which non-Q data and references have been upgraded for incorporation in the PMR via the constituent models and analyses developed in compliance with AP-3.10Q. The first version of the PMR will discuss how non-Q data referenced in the document are tracked with "TBVs."

In addition, the QA status of data and software will be discussed. This will include a table of the QA status of natural systems input data, a table of the QA status of design input data, and a table of the QA status of software. Specific demonstrations of compliance with quality assurance requirements will follow in later chapters and will be discussed in the referenced AP-3.10Q analyses.

1.4 RELATIONSHIP TO OTHER PROCESS MODEL REPORTS AND KEY PROJECT DOCUMENTS

This section discusses how this PMR relates to the other PMRs in terms of interfaces, ties, and overlaps. It includes a list of all the PMRs and a summary-level purpose and description of each. The section explains how this PMR relates to documents such as the Yucca Mountain Site Description, the Natural Analogs report, the Natural Resources report, topical reports, the SRR, the LA, and other documents as considered applicable and appropriate by the PMR authors. It also describes the relationship between the subject matter of this PMR and other contributory or subsequent process models. This discussion may overlap with some of the information under Section 1.2, "Scope" above. The following represent data/information feeds to and or from the NFE PMR.

- UZ Flow and Transport PMR
- Repository Design Documents
- EBS PMR
- Waste Package Degradation PMR

1.5 OVERVIEW DESCRIPTION AND RESULTS OF MODELS AND ABSTRACTION

This section provides a high-level overview of the NFE models, the results of the models, the abstractions of the models, the results of the abstractions, application of the models in the PMR, and the implications for repository performance. This section basically summarizes the information that is provided in more detail in Chapter 3 and in much greater detail in the reference AP-3.10Q analyses. The section also contains a summary of Chapter 4 that integrates the PMR models, abstractions, and analyses. The section is intended to support the reader who wants to get the gist of the report without examining it in detail.

CHAPTER 2.0 EVOLUTION OF THE PROCESS MODEL(S)

2.1 OVERVIEW

Provide background against which the PMR is being developed. Describes the documentation structure of which the PMR is a part, explain the philosophy for developing the PMRs, and describe why this specific PMR is being developed.

Summarize the development of the specific process models and abstractions by describing the conceptual approach used to develop the process models and abstractions. Provide references to sections of Chapter 3 that contain the descriptions of the technical details associated with the development of the process models and abstractions.

2.2 PREVIOUS NEAR-FIELD MODELING

The chapter provides a summary of the previous treatment of the near-field environment (background of previous modeling and abstraction). Included in this description is the treatment of the near-field environment in previous TSPAs

2.3 NEAR-FIELD ENVIRONMENT WORKSHOPS

This section provides a description of the conduct and results of performance assessment workshops on the near-field environment. This includes a brief overview and description of the purpose of the workshop.

2.4 FEATURES, EVENTS, AND PROCESSES ASSOCIATED WITH THE NFE PMR

This section describes the results of screening the features, events, and processes. Describe the features, events, and processes included; the features, events, and processes excluded and include the basis for eliminating features, events, and processes. Document the rationale for the elimination or retention of any scenario considered.

CHAPTER 3.0 MODELS AND ABSTRACTIONS

Chapter 3 describes the development of the process-level models, model abstractions, and supporting analyses that address the near-field environment process. Discussions will include the relationships among the process-level models, model abstractions, data, and supporting analyses.

3.0 INTRODUCTION

Section 3.0 identifies and introduces the models that are the principal subject of the chapter and shows the relationship among the various components that are discussed in the chapter.

3.1 ESF AND LBT FIELD THERMAL TESTING RESULTS

The ESF thermal tests and the large block test will be used to help specify appropriate conceptual flow models, thermal perturbations to hydrologic flow properties, coupled process data specifications and initial conditions, and assessments of implementation of ambient flow hydrologic properties in thermally driven models. This includes experimentally determined data taken from the single heater test and drift-scale test at the ESF and the large block test.

3.1.1 Single Heater Test

This includes experimentally determined data taken from the single heater test.

3.1.2 Drift-Scale Heater Test

This includes experimentally determined data taken from the drift-scale test at the ESF.

3.1.3 Large Block Test

This includes experimentally determined data taken from the large block test.

3.2 HOW THE UZ FLOW AND TRANSPORT INPUTS ARE APPLIED IN THE NFE MODELS

A description of how hydrologic flow properties, geologic framework model, infiltration rates, climate states, and conceptual flow models as implemented in the UZFT PMR are applied in the process-level models featured in this PMR.

3.3 HOW THE REPOSITORY DESIGN INPUTS ARE APPLIED IN THE NFE MODELS

A description of how design specifications for the reference repository design are implemented in the process-level models featured in this PMR. This includes determination of discrete waste package layouts, repository area/elevation/location, individual decay heat curves, and repository-averaged heat output for all wastes.

3.4 MODEL DESCRIPTIONS

The bases for the scopes of the models (number of processes and/or sub-models included) are explained in terms of the conceptual models that provide the bases for the process models. This section also describes the layout of the chapter discussion of those components. Sections 3.4 through 3.7 provide the primary descriptions of the Near-Field Environment process model components. These models will feed the NFE abstracted models.

3.4.1 Impact on Emplacement Drift Thermodynamic Environment

A description of the process-level models used to develop the temperature, relative humidity, and air mass fraction at the drip-shield surface and the waste package surface. The models will be able to provide a determination of how near-field host rock THC processes impact the near-field drift environment.

3.4.1.1 Introduction

3.4.1.2 QA

3.4.2.3 Importance Of Concept

3.4.3.4 Model Assumptions

3.4.4.5 Relevant Data

3.4.5.6 Process-Level Models, Methodology, And Approach

3.4.6.7 Model Limitations/Uncertainties

3.4.7.8 Results For Base Case

3.4.8.9 Sensitivity Analysis

3.4.8.10 Summary

3.4.2 Impact On Emplacement Drift Seepage Water Chemical Content And Gas Compositions

A description of the process-level thermal-hydrologic-chemical models used to develop the incoming (into the drift) water chemistry and gas-phase compositions. This model is dependent on the THC parameters and physical processes in the near-field rock directly surrounding the emplacement drifts.

3.4.2.1 Introduction

3.4.2.2 QA

3.4.2.3 Importance Of Concept

3.4.2.4 Model Assumptions

3.4.2.5 Relevant Data

3.4.2.6 Process-Level Models, Methodology, And Approach

3.4.2.7 Model Limitations/Uncertainties

3.4.2.8 Results For Base Case

3.4.2.9 Sensitivity Analysis

3.4.2.10 Summary

3.4.3 THM Processes in the Near- Field Host Rock

A description of the process-level models used to determine the impact of thermal-hydrologic-mechanical effects on near-field quantities such as the flow properties used in drift seepage calculations and drift thermodynamic environment calculations.

3.4.3.1 Introduction

3.4.3.2 QA

3.4.3.3 Importance Of Concept

3.4.3.4 Model Assumptions

3.4.3.5 Relevant Data

3.4.3.6 Process-Level Models, Methodology, And Approach

3.4.3.7 Model Limitations/Uncertainties

3.4.3.8 Results For Base Case

3.4.3.9 Sensitivity Analysis

3.4.3.10 Summary

3.4.4 Thermal Effects on Emplacement Drift Seepage

A description of the process-level models and methods applied to determine the impact of thermal effects on emplacement drift seepage. This will be performed using the percolation flux above the crown of the drift at different repository locations (a function of the number of repository subregions determined by TSPA) for different waste package types (commercial, high-level waste, and DOE SNF).

3.4.4.1 Introduction

3.4.4.2 QA

3.4.4.3 Importance Of Concept

3.4.4.4 Model Assumptions

3.4.4.5 Relevant Data

3.4.4.6 Process-Level Models, Methodology, And Approach

3.4.4.7 Model Limitations/Uncertainties

3.4.4.8 Results For Base Case

3.4.4.9 Sensitivity Analysis

3.4.4.10 Summary

3.4.5 TH Multiscale Model and Abstraction Method--Assumption Testing and Analysis Introduction

A series of heat transfer and fluid flow analyses used to justify the model assumptions and simplifications as applied in the near-field process-level models and sub-models. NRC and other review comments made during TSPA-VA drive these analyses.

3.4.5.1 Introduction

3.4.5.2 QA

3.4.5.3 Importance Of Concept

3.4.5.4 Model Assumptions

3.4.5.5 Relevant Data

3.4.5.6 Process-Level Models, Methodology, And Approach

3.4.5.7 Model Limitations/Uncertainties

3.4.5.8 Results For Base Case

3.4.5.9 Sensitivity Analysis

3.4.5.10 Summary

3.4.6 THC Processes in the Near-Field Host Rock

This section describes the base case analyses, results, and PA abstractions as obtained from the process-level model analyses for the THC Process in the Near-Field Host Rock as described below, including temperature, relative humidity, air mass fraction, seepage quantities and chemistry. This section will also define what the base case runs for the near-field environment including climate states, infiltration rates, property sets, and rock-mineral-water specifications in the chemical models. Base case runs defined by the repository design include areal mass loading, repository layout and configuration, and waste package heat output and layout representation.

3.4.6.1 Thermodynamic Environment In The Emplacement Drift

3.4.6.1.1 Temperature

3.4.6.1.2 Relative Humidity

3.4.6.1.3 Air Mass Fraction

3.4.6.2 Seepage Water Content And Gas Composition

3.4.6.2.1 Chemical Content Of Entering Water

3.4.6.2.2 Gas Chemical Content

3.4.6.3 PA Abstraction Results

3.4.7 THM Processes in the Near-Field Host Rock

Describes the thermo-hydrological-mechanical base case analyses, results, and PA abstractions as obtained from the process-level model analyses for these coupled processes as previously described. This section will also define what the base case runs for the near-field environment including climate states, infiltration rates, property sets, and rock-mineral-water specifications in the chemical models. Base case runs defined by the repository design include areal mass loading, repository layout and configuration, and waste package heat output and layout representation.

3.4.7.1 Alteration of the large-scale processes

3.4.7.1.1 Gas Phase Flux Values

3.4.7.1.2 Air Mass Fraction

3.4.7.1.3 Liquid Phase Flux Below The Repository

3.4.7.2 Alteration Of Near-Field Processes

3.4.7.3 PA Abstraction Results

3.4.8 Thermal Effects on Emplacement Drift Seepage

The thermal effects on drift seepage are described for the base case analyses, results, and PA abstractions as obtained from the process-level model analyses previously described. This section will also define what the base case runs for the near-field environment including climate states, infiltration rates, property sets, and rock-mineral-water specifications in the chemical models. Base case runs defined by the repository design include areal mass loading, repository layout and configuration, and waste package heat output and layout representation.

3.4.8.1 Waste Package Variability

3.4.8.2 Thermal Alteration On Seepage Quantities

3.4.8.2.1 Thermal Factor On Seepage Fraction

3.4.8.2.2 Thermal Factor On Seepage Volume Flow Rate

3.4.8.3 PA Abstraction Results

3.4.9 THC Processes In The Near-Field Host Rock

This section provides a description of the THC sensitivity models and analyses that were performed to consider variability in properties and possible materials that were not directly addressed in the base case analyses discussed in 3.4.6. This section will document the sensitivity analyses results, and PA abstractions.

3.4.9.1 Consideration Of Additional/Different Minerals

3.4.9.2 Consideration Of Different/Bounding Chemical Reaction Kinetics

3.4.9.3 Consideration Of Ranges Of Reactive Mineral Surface Areas

3.4.9.4 PA Abstraction Results

3.4.10 THM Processes In The Near-Field Host Rock

This section provides a description of the sensitivity models and analyses for thermal-hydrological-mechanical processes that were performed to consider differing constitutive formulations or conceptualizations and geologic interpretations from those used in the base-case analyses discussed in 3.4.7. This section will document the sensitivity analyses results, and PA abstractions.

3.4.10.1 Consideration Of Bounding Constitutive Relationships Between Thermal Stress And Flow Properties

3.4.10.2 Consideration Of Rockfall Effects On Emplacement Drift Thermodynamic Environment

3.4.10.3 PA Abstraction Results

3.4.11 Thermal Effects On Emplacement Drift Seepage

This section provides a description of the sensitivity models and analyses for thermal effects on drift seepage to consider design options that were not considered in the base-case described in section3.4.8. This section will document the sensitivity analyses results, and PA abstractions.

3.4.11.1 Alternative Consideration Of Waste Package Variability

3.4.11.2 Alternative Consideration Of Repository Location

3.4.11.3 Rockfall On T And RH In Drift (If No Backfill)

3.4.11.4 PA Abstraction Results

3.5 DATA QUALIFICATION

This section demonstrates the qualification of any data necessary to support use of the model and its sub-models whose qualification has not been demonstrated in the previous sections. Summaries of, and cross-references to, discussions of data pedigrees in AP-3.10Q reports are also provided, as appropriate.

3.6 SUMMARY OF OTHER VIEWS & ALTERNATIVE CONCEPTUAL MODELS

This section documents credible opposing views to the approaches and methods described in the PMR for the model under discussion. The section consists of a relatively brief summary of the opposing view or position, accompanied by an explanation of why the Project does not subscribe to the opposing view or position. To the extent that compensatory measures have been or will be taken to deal with the opposing view, those measures are also described in this section.

The chapter or section also discusses findings of reviewers external to the Project of the models and processes associated with the PMR, and it describes how the findings have been satisfactorily addressed.

3.5.1 Expert Elicitation

Expert elicitation was used to solicit the judgement of nationally and internationally recognized scientists in quantifying uncertainty in the parameter values used in near-field environment models. This section summarizes the results of the expert elicitations.

3.5.2 TSPA Peer Review Panel on TSPA-VA

This section summarizes the comments of the TSPA Peer Review panel on the TSPA-VA.

3.5.3 MTS Technical Comments on TSPA-VA

This section summarizes the comments of the MTS on the TSPA-VA.

CHAPTER 4.0 RELATIONSHIP WITH THE NUCLEAR REGULATORY COMMISSION (NRC) ISSUE RESOLUTION STATUS REPORTS

Because the NRC has indicated it plans to structure its review of issues that are subjects of PMRs around the NRC's designated Key Technical Issues (KTI) and Issue Resolution Status Reports (IRSR), this chapter of the PMR describes how the acceptance criteria in the IRSRs have been addressed.

5.0 INTRODUCTION

This introductory subsection summarizes how the information in this PMR addresses various NRC Key Technical Issues (KTIs) as described in the related Issue Resolution Status Reports (IRSRs).

5.1 NRC IRSRS AND KTIS

The NRC has determined that resolution of its designated KTIs is crucial to licensing the repository. The NRC staff has issued various IRSRs that describe the status of the KTIs from the NRC's perspective. They also provide subissues and acceptance criteria for each KTI. Some of the KTIs may correspond to, or overlap with, the issues and processes that the PMR addresses. This section of the PMR describes how each KTI and its constituent subissues and acceptance criteria have been addressed through the PMR. Each subsection identifies a Key Technical Issue, its subissues, and associated acceptance criteria that are related to the PMR. The subsections discuss how the PMR addresses the acceptance criteria identified for each subissue of each KTI. In many cases, a given PMR only partially addresses a given KTI, and that fact is noted as appropriate.

REFERENCES

This chapter contains the complete reference list for the document.

APPENDICES

The appendices contain supporting information deemed appropriate for inclusion in the PMR (if any) but at too great a level of detail for the body of the report.

WASTE PACKAGE DEGRADATION

PROCESS MODEL REPORT

CHAPTER 1.0 INTRODUCTION

This chapter provides the "up front" information necessary for the reader to understand the purposes of the report, its basic organization, and related issues. This chapter also provides a high-level summary of how the Waste Package Degradation PMR relates to technical topics presented in the other PMRs (and non-PMRs as appropriate), and key Project documents including topical reports, the Environmental Impact Statement (EIS), the Site Recommendation Report (SRR), and the License Application (LA).

1.0 INTRODUCTION

Section 1.0 contains introductory text that briefly describes the goal of the Yucca Mountain Project, which is to determine suitability of the Yucca Mountain site for disposal of high-level nuclear waste. If the site is found suitable, the goal is to then seek a license to construct and subsequently to operate and eventually close a high-level waste disposal facility. It goes on to briefly describe the role of the PMR in meeting those goals. Finally, the section summarizes the layout of the PMR.

1.1 OBJECTIVE

This section provides the objective (or objectives) of the PMR (what its production is intended to accomplish). Briefly and generically, the objective is to compile in one place, as a stand-alone report, a synthesis of all the necessary and sufficient technical information, related to the PMR topic, that the Project will be relying upon to make its site suitability evaluation and ultimately the licensing argument pertaining to a particular process model. The technical information consists of data, analyses, models, software and supporting documents used to develop the PMR model (or models) and defend the applicability of the model for its intended purpose of evaluating aspect(s) of postclosure performance of the Yucca Mountain repository system. The PMR serves as an important reference for Total System Performance Assessment (TSPA) and key Program milestone documents (EIS, SRR, and LA) and is written for a readership of knowledgeable persons in technical and regulatory fields. Many of the objectives are common to all the PMRs, though one or more may also be specific to a given PMR.

1.2 SCOPE

The Waste Package Degradation PMR describes processes that will lead to waste package degradation (for example, the corrosion of the waste package materials within the near-field environment). This PMR provides information about the thermal, hydrologic, and geochemical processes acting on waste package surfaces that are important environmental factors affecting waste package lifetime. The PMR describes inputs from other PMRs, such as the Unsaturated Zone (UZ) Flow and Transport and Near-Field PMRs, and outputs to the UZ Flow and Transport model, EBS design and TSPA. The emphasis of the discussion of model inputs and outputs is on information needed for the assessment of postclosure performance.

This section also describes where to find relevant subject matter not included in the PMR. References to related discussions in Chapter 2 are provided.

1.3 QUALITY ASSURANCE

This section explains the quality assurance controls under which the PMR has been developed. The PMR is expected to be designated as quality-affecting through QAP-2-0 analysis. As such the PMR is developed under AP-3.11Q. The section also discusses the method through which non-Q data and references have been upgraded for incorporation in the PMR via the constituent models and analyses developed in compliance with AP-3.10Q. In the case of the first version of the PMR, discussions include how non-Q data referenced in the document are tracked with "TBVs." This section provides a general discussion, with the more specific demonstrations of compliance with quality assurance requirements to follow in later chapters and to be discussed in the referenced AP-3.10Q analyses.

1.4 RELATIONSHIP TO OTHER PROCESS MODEL REPORTS AND KEY PROJECT DOCUMENTS

This section discusses how this PMR relates to the other PMR in terms of interfaces and overlaps. It includes a list of all the related PMRs and a summary-level purpose and description of each. The section explains how this PMR relates to documents such as the Yucca Mountain Site Description, the Natural Analogs report, the Natural Resources report, topical reports, the SRR, the LA, and other documents as considered applicable and appropriate by the PMR authors. It also describes the relationship between the subject matter of this PMR and other contributory or subsequent process models. This discussion may overlap with some of the information under Section 1.2, "Scope" above.

1.5 OVERVIEW DESCRIPTION AND RESULTS OF MODELS AND ABSTRACTION

This section provides a high-level description of the models, the abstractions of the models, the results of abstractions, and application of the models in the PMR. This section basically summarizes the information that is provided in more detail in Chapter 3 and in much greater detail in the reference AP-3.10Q analyses. The section also contains a summary of Chapter 4 that integrates the PMR models, abstractions, and analyses. The section is intended to support the reader who wants to get the gist of the report without examining it in great detail.

CHAPTER 2.0 EVOLUTION OF THE PROCESS MODEL(S)

This chapter provides perspective on the background against which the PMR is being developed and describes the documentation structure of which the PMR is a part.

First, the chapter explains the philosophy for developing the PMRs, and why this specific PMR is being developed.

Next, the chapter provides a summary of previous treatment of the subject issue (background of previous modeling and abstraction).

The chapter then summarizes the development of the specific process models and abstractions that are its subject by describing the conceptual approach used to develop the process models and abstractions. It provides references to sections of Chapter 3 that contain the descriptions of the technical details associated with the development of the process models and abstractions.

The discussion includes a description of the relationship between the PMR and the constituent sub-process models, abstraction models, and analyses (as applicable) developed under AP 3.10Q. Whereas section 1.2 uses a flowchart to describe the information flow associated with the subject of the PMR, this chapter discusses the same subject but in terms of the document structure (AP-3.10Qs, the PMR itself, and other documents as applicable).

CHAPTER 3.0 MODELS AND ABSTRACTIONS

Chapter 3 describes the models, abstractions, and analyses that address the process that is the subject of the PMR. Discussions will include the relationships among the models, abstractions, data, and analyses.

3.0 INTRODUCTION

Section 3.0 identifies and introduces the models that are the principal subject of the chapter and shows the relationship among the various components that are discussed in the chapter. The bases for the scopes of the models (number of processes and/or sub-models included) are explained in terms of the conceptual models that provide the bases for the process models. This section also describes the layout of the chapter discussion of those components.

3.1 MODEL DESCRIPTIONS

This section describes the set of models that is the subject of the PMR consistent with the corresponding AP-3.10Q reports, including its supporting codes, components, sub-models, and/or analyses. Sub-models that make up the model are identified. The section summarizes the development of the process models as described in greater detail in the corresponding AP-3.10Q report. Discussions in this section will include descriptions of data feeds from AP-3.10Q analyses and reports external to but summarized in this PMR.

3.1.1 Overview of Waste Package and EBS Design

This section provides an overview of the information on the waste package and EBS designs relevant to the waste package materials degradation modeling such as:
1) Waste package materials and design specification, 2) Waste package fabrication process including closure weld, 3) Waste Package Support in Emplacement Drift and 4) Waste Package Drip Shield- drip shield materials, design specification, fabrication process, and emplacement process in drift.

3.1.1.1 Discussion of Relevant Data and data Uncertainties

3.1.1.2 Model Assumptions

3.1.1.3 Model Description

3.1.1.4 Model Results

3.1.2 Juvenile Failures

AP3.10Q on 1) the probability of waste package materials defect and their uncertainty and variability, 2) waste package fabrication process including closure weld, the probability of waste package fabrication defect and their uncertainty and variability, and 3) consequence of the defect on waste package failure (e.g., number of failure sites and opening size distribution) and their uncertainty and variability.

3.1.2.1 Discussion of Relevant Data and Data Uncertainties

3.1.2.2 Model Assumptions

3.1.2.3 Model Description

3.1.2.4 Model Results

3.1.3 Environment on the Surface of the Waste Package Barrier Materials

AP3.10Qs on models and analyses for each of the WP barriers (and drip shield if used) for 1) local corrosion condition evolution as a function of time and space/location in the presence and absence of drips, and 2) uncertainty and variability of the corrosion conditions

3.1.3.1 Discussion of Relevant Data and data Uncertainties

3.1.3.2 Model Assumptions

3.1.3.3 Model Description

3.1.3.4 Model Results

3.1.4 Phase Stability and Aging

AP3.10Qs on models and analyses for each of the WP barriers (and drip shield if used) for 1) degradation process resulting from long-term exposure to elevated temperatures, 2) degradation rate as a function of exposure conditions, 3) failure mode characteristics (e.g., number failure sites and opening size), and 4) uncertainty and variability of the above degradation process

3.1.4.1 Discussion of Relevant Data and data Uncertainties

3.1.4.2 Model Assumptions

3.1.4.3 Model Description

3.1.4.4 Model Results

3.1.5 General Corrosion

AP3.10Qs on models and analyses for each of the WP barriers (and drip shield if used). The process model for this will incorporate the following sub-models.
Dry Oxidation: Models and analyses for each of the WP barriers (and drip shield if used) for 1) degradation process from dry oxidation, 2) degradation rate as a function of exposure conditions, 3) failure mode characteristics (e.g., number failure sites and opening size), and 4) uncertainty and variability of the above degradation process.

Humid air corrosion: Models and analyses for each of the WP barriers (and drip shield if used) for 1) RH and T thresholds for corrosion initiation in the presence and absence of drips, and 2) uncertainty and variability of the thresholds.

Aqueous corrosion: Models and analyses for each of the WP barriers (and drip shield if used) for 1) general corrosion degradation process, 2) general corrosion rate as a function of time and local corrosion conditions, 3) failure mode characteristics (e.g., number failure sites and opening size), and 4) uncertainty and variability of the corrosion rate

3.1.5.1 Discussion of Relevant Data and data Uncertainties

3.1.5.2 Model Assumptions

3.1.5.3 Model Description

3.1.5.4 Model Results

3.1.6 Localized Corrosion

Analyses for each of the WP barriers (and drip shield if used) for the thresholds of localized corrosion initiation in the presence and absence of drips, and uncertainty and variability of the thresholds.

AP3.10Qs on models and analyses for each of the WP barriers (and drip shield if used) for 1) localized corrosion degradation process, 2) localized corrosion rate as a function of time and local corrosion conditions, 3) failure mode characteristics (e.g., number failure sites and opening size), and 4) uncertainty and variability of the corrosion rate

3.1.6.1 Discussion of Relevant Data and data Uncertainties

3.1.6.2 Model Assumptions

3.1.6.3 Model Description

3.1.6.4 Model Results

3.1.7 Stress Corrosion Cracking (SCC)

Analyses for each of the WP barriers (and drip shield if used) for the thresholds of SCC initiation in the presence and absence of drips, and uncertainty and variability of the thresholds.

AP3.10Qs on models and analyses for each of the WP barriers (and drip shield if used) for 1) SCC process, 2) SCC rate as a function of time and local corrosion and stress conditions, 3) failure mode characteristics (e.g., number failure sites and opening size), and 4) uncertainty and variability of the corrosion rate.

3.1.7.1 Discussion of Relevant Data and data Uncertainties

3.1.7.2 Model Assumptions

3.1.7.3 Model Description

3.1.7.4 Model Results

3.1.8 Hydrogen Induced Cracking

Analyses for each of the WP barriers (and drip shield if used) for the thresholds of crack initiation by HIC in the presence and absence of drips, and uncertainty and variability of the thresholds

AP3.10Qs on models and analyses for each of the WP barriers (and drip shield if used) for 1) HIC process, 2) HIC crack propagation rate as a function of time and local corrosion and stress conditions, 3) failure mode characteristics (e.g., number failure sites and opening size), and 4) uncertainty and variability of the corrosion rate

3.1.8.1 Discussion of Relevant Data and data Uncertainties

3.1.8.2 Model Assumptions

3.1.8.3 Model Description

3.1.8.4 Model Results

3.1.9 Galvanic Coupling Effects

AP3.10Qs (if needed) on models and analyses for each of the WP barriers (and drip shield if used) for 1) galvanic coupling process, 2) its effects on local corrosion conditions and corrosion processes, and 3) uncertainty and variability of the galvanic coupling effect

3.1.9.1 Discussion of Relevant Data and data Uncertainties

3.1.9.2 Model Assumptions

3.1.9.3 Model Description

3.1.9.4 Model Results

3.1.10 Mechanical Failures due to Rockfall (including seismically-induced)

Analyses for rockfall frequency and rock size distribution as a function of time, and uncertainty and variability of the parameters. AP3.10Qs on models and analyses for 1) critical rock size to fail (cause through-cracks in) waste package as a function of remaining waste package structural compoments (e.g., barrier thickness), 2) failure mode characteristics (e.g., number failure sites and opening size), and 3) uncertainty and variability of the rock-fall failure processes

3.1.10.1 Discussion of Relevant Data and data Uncertainties

3.1.10.2 Model Assumptions

3.1.10.3 Model Description

3.1.10.4 Model Results

3.1.11 Failure by Non-Conventional Degradation Processes

Analyses for waste package failure that is caused by non-conventional degradation processes, presenting 1) description of likely processes causing the failure, 2) probability of the failure, 3) time period (or distribution) at the failure, 4) failure mode characteristics (e.g., number failure sites and opening size), and 5) uncertainty and variability of the failure processes

3.2 INTEGRATED MODEL DEVELOPMENT

This section discusses the uncertainties in the model/sub-models and the assumptions and bases thereof associated with the uncertainties.

3.2.1 Model Uncertainties

This Section discusses the uncertainties in the process model that is the topic of this PMR and the assumptions and bases thereof associated with the uncertainties.

3.2.2 Model Validation

This section demonstrates the validity of the model [See Quality Assurance Requirements and Description (DOE/RW-0333P) Glossary and AP-3.10Q for definitions of model validation] and its sub-models and discusses the suitability of the model for its intended application. It includes demonstration of the validity of the data used to support the model validation, as well as demonstration of the validity of the codes that support the models. Results of expert elicitations used to support model validation are included. The discussion summarizes use of natural and man-made analogues in the model validation as appropriate.

3.2.3 Abstraction of the Models

This section describes the method of abstracting the model and its sub-models into the TSPA. Abstraction of the process-level models described in Section 3.1 will be developed only for those corrosion modes and processes that the detailed analysis shows they have significant effects on waste package performance and warrants their inclusion in the TSPA. Results of expert elicitations and abstraction workshops are included as appropriate. Discussions include any assumptions needed to support the abstraction and descriptions of the approach taken to deal with the uncertainties in the model abstraction process. Details of the model abstraction process will be documented in the corresponding AP-3.10Q reports. The abstracted models will be implemented in the waste package degradation model.

3.2.4 Validity of the Abstraction

This section contains a demonstration of the validity of the abstraction. Results of peer reviews or other evaluations of the model abstraction process are included. If the peer reviews or other evaluations were not favorable, cross-references are provided to discussions of such results in Section 3.4. The discussion summarizes use of natural and man-made analogues in validating the abstraction as appropriate.

3.3 DATA QUALIFICATION

This section demonstrates the qualification of any data necessary to support use of the model and its sub-models whose qualification has not been demonstrated in the previous sections. Summaries of, and cross-references to, discussions of data pedigrees in AP-3.10Q reports are also provided, as appropriate.

3.4 SUMMARY OF OTHER VIEWS & ALTERNATIVE CONCEPTUAL MODELS

This section documents credible opposing views to the approaches and methods described in the PMR for the model under discussion. The section consists of a relatively brief summary of the opposing view or position, accompanied by an explanation of why the Project does not subscribe to the opposing view or position. To the extent that compensatory measures have been or will be taken to deal with the opposing view, those measures are also described in this section.

The chapter or section also discusses findings of reviewers external to the Project of the models and processes associated with the PMR, and it describes how the findings have been satisfactorily addressed.

CHAPTER 4.0 RELATIONSHIP WITH THE NUCLEAR REGULATORY COMMISSION (NRC) ISSUE RESOLUTION STATUS REPORTS

Because the NRC has indicated it plans to structure its review of issues that are subjects of PMRs around the NRC's designated Key Technical Issues (KTI) and Issue Resolution Status Reports (IRSR), this chapter of the PMR describes how the acceptance criteria in the IRSRs specific to the waste package have been addressed.

4.1 INTRODUCTION

This introductory subsection summarizes the NRC's Container Lifetime and Source Term (CLST) KTI and IRSR effort. The NRC has determined that resolution of its designated KTIs is crucial to licensing the repository. The NRC staff has issued an IRSR that describe the status of the CLST KTI from the NRC's perspective and provide subissues and acceptance criteria. This section of the PMR describes how CLST KTI and its constituent subissues and acceptance criteria have been addressed through the PMR.

4.2 THROUGH 4.X RELATIONSHIP OF PMR TO KTIS

Each subsection that follows identifies a Key Technical Issue, its subissues, and associated acceptance criteria that are related to the PMR. The subsections discuss how the PMR addresses the acceptance criteria identified for each subissue of each KTI. In many cases a given PMR only partially addresses a given KTI, and that fact is noted as appropriate.

REFERENCES

This chapter contains the complete reference list for the document.

APPENDICES

The appendices contain supporting information deemed appropriate for inclusion in the PMR (if any) but at too great a level of detail for the body of the report.

WASTE FORM DEGRADATION PROCESS MODEL REPORT

CHAPTER 1 INTRODUCTION

This chapter provides the "up front" information necessary for the reader to understand the purposes of the report, its basic organization, and related issues. It also supports the reader who desires a quick look at the document without reviewing it in great detail. This chapter also provides a high-level summary of how the WF PMR relates to technical topics presented in the other PMRs (and non-PMRs as appropriate), and key Project documents including topical reports, the Environmental Impact Statement (EIS), the Site Recommendation Report (SRR), and the License Application (LA).

1.0 INTRODUCTION

Section 1.0 contains introductory text that briefly describes the goal of the Yucca Mountain Project, which is to determine suitability of the Yucca Mountain site for disposal of high-level nuclear waste. If the site is found suitable, the goal is to then seek a license to construct and subsequently to operate and eventually close a high-level waste disposal facility. It goes on to briefly describe the role of the WF PMR in meeting those goals. Finally, the section summarizes the layout of the WF PMR.

1.1 OBJECTIVE

This section provides the objective (or objectives) of the WF PMR (what its production is intended to accomplish). Briefly and generically, the objective is to compile in one place, as a stand-alone report, a synthesis of all the necessary and sufficient technical information, related to the WF PMR topic, that the Project will be relying upon to make its site suitability evaluation and ultimately the licensing argument pertaining to a particular process model. The technical information consists of data, analyses, models, software and supporting documents used to develop the WF PMR model (or models) and defend the applicability of the model for its intended purpose of evaluating aspect(s) of postclosure performance of the Yucca Mountain repository system. The WF PMR serves as an important reference for Total System Performance Assessment (TSPA) and key Program milestone documents (EIS, SRR, and LA) and is written for a readership of knowledgeable persons in technical and regulatory fields. Many of the objectives are common to all the PMRs, though one or more may also be specific to a given PMR.

1.2 SCOPE

This section explains the information presented in and the content of the WF PMR. It uses one or more flowcharts to show the evolution of information from data to TSPA output, showing in the flowcharts what parts of the evolution are included in the WF PMR. The section also describes where to find relevant subject matter not included in the WF PMR. References to related discussions in Chapter 2 are provided.

The Waste Form Degradation PMR describes the waste characteristics that are expected to minimize the rate of release of radionuclides. Discussions include cladding degradation and waste form dissolution. The WF PMR describes the manner in which the waste forms will break down and how the manner of break down is expected to affect the release of radionuclides to the immediately surrounding environment. The WF PMR also describes inputs from other PMRs, especially the Waste Package Degradation PMR, and outputs to the UZ Flow and Transport, EBS design, and TSPA. The emphasis of the discussion of model inputs and outputs is on information needed for the assessment of postclosure performance.

1.3 QUALITY ASSURANCE

This section explains the quality assurance controls under which the WF PMR has been developed. The WF PMR is expected to be designated as quality-affecting through QAP-2-0 analysis. As such the WF PMR is developed under AP-3.11Q. The section also discusses the method through which non-Q data and references have been upgraded for incorporation in the WF PMR via the constituent models and analyses developed in compliance with AP-3.10Q. In the case of the first version of the WF PMR, discussions include how non-Q data referenced in the document are tracked with "TBVs." This section provides a general discussion, with the more specific demonstrations of compliance with quality assurance requirements to follow in later chapters and to be discussed in the referenced AP-3.10Q analyses.

1.4 RELATIONSHIP TO OTHER PROCESS MODEL REPORTS AND KEY PROJECT DOCUMENTS

This section discusses how the WF PMR relates to the others in terms of interfaces and overlaps. It includes a list of all the PMRs and a summary-level purpose and description of each. The section explains how the WF PMR relates to documents such as the Yucca Mountain Site Description, the Natural Analogs report, the Natural Resources report, topical reports, the SRR, the LA, and other documents as considered applicable and appropriate by the WF PMR authors. It also describes the relationship between the subject matter of the WF PMR and other contributory or subsequent process models. This discussion may overlap with some of the information under Section 1.2, "Scope" above.

1.5 OVERVIEW DESCRIPTION AND RESULTS OF MODELS AND ABSTRACTION

This section provides a high-level description of the models, the abstractions of the models, the results of abstractions, and application of the models in the WF PMR. This section basically summarizes the information that is provided in more detail in Chapter 3 and in much greater detail in the reference AP-3.10Q analyses. The section also contains a summary of Chapter 4 that integrates the WF PMR models, abstractions, and analyses. The section is intended to support the reader who wants to get the gist of the report without examining it in great detail.

CHAPTER 2 EVOLUTION OF THE PROCESS MODEL(S)

This chapter provides perspective on the background against which the WF PMR is being developed and describes the documentation structure of which the WF PMR is a part.

First, the chapter explains the philosophy for developing the PMRs, and why the WF PMR is being developed.

Next, the chapter provides a summary of previous treatment of the subject issue (background of previous modeling and abstraction).

The chapter then summarizes the development of the specific process models and abstractions that are its subject by describing the conceptual approach used to develop the process models and abstractions. It provides references to sections of Chapter 3 that contain the descriptions of the technical details associated with the development of the process models and abstractions.

The discussion includes a description of the relationship between the WF PMR and the constituent sub-process models, abstraction models, and analyses (as applicable) developed under AP 3.10Q. Whereas section 1.2 uses a flowchart to describe the information flow associated with the subject of the WF PMR, this chapter discusses the same subject but in terms of the document structure (AP-3.10Qs, the WF PMR itself, and other documents as applicable).

This chapter will also include a section on the FEP (Features, Events and Processes) screening process. The section will discuss the process and provide a table of FEPs covered in the WF PMR. The table will include pointers to sections in chapter 3 where the include/exclude decision for each FEP is summarized.

CHAPTER 3 MODELS AND ABSTRACTIONS

Chapter 3 describes the models, abstractions, and analyses that address the process that is the subject of the WF PMR. Discussions will include the relationships among the models, abstractions, data, and analyses.

3.0 INTRODUCTION

Section 3.0 identifies and introduces the models that are the principal subject of the chapter and shows the relationship among the various components that are discussed in the chapter. The bases for the scopes of the models (number of processes and/or sub-models included) are explained in terms of the conceptual models that provide the bases for the process models. This section also describes the layout of the chapter discussion of those components.

3.1 INVENTORY

This section summarizes the analyses performed to obtain inventory of the radionuclides for release and transport modeling in TSPA-SR.

3.1.1 General Description of the Waste Types

This sub-section provides a general description of the broad range of waste types including waste characteristics such as burn-up, enrichment, disposal options, etc.

3.1.2 Groupings of waste types for TSPA calculations

The three types modeled in the TSPA-VA were CSNF, HLW and DSNF. This subsection presents the new analyses for the waste groups modeled with cross-references to the types used for heat generation curves in TH modeling.

3.1.3 Tables of Isotope Inventory Per Package for Each Group

This section presents the results of the binning of the waste streams into groups, including uncertainty discussion, and data QA tracking.

3.1.4 Selection of Isotopes for Inclusion Within TSPA Calculations

This section summarizes the sensitivity analysis and selection of most important isotopes for the three types of TSPA calculations (Safety case, Human Intrusion, Disruptive Events), including uncertainty discussion, and comparison to important isotope lists in other PA's.

3.2 COMMERCIAL SPENT NUCLEAR FUEL (CSNF) CLAD DEGRADATION

This section presents the analysis of all the possible degradation modes of CSNF clad, and the models used to describe these degradation modes within the TSPA-SR.

3.2.1 Initial State Of Clad

This subsection describes the initial state of the clad as the fuel assemblies are removed from the reactor. It includes discussion data QA and uncertainty. From the literature failure rates, the fraction of fuel with failed cladding will be derived for the initially failed clad model. A discussion of clad that has damage but has not failed will be included.

3.2.2 In-WP Temperature History

This subsection summarizes the calculation of expected and extreme-case temperature histories, with cross-reference to TH model. It will include discussion of uncertainty, validation, abstraction, validation of abstraction, results, data QA.

3.2.3 Screened-Out Failure Modes

This subsection briefly summarizes the analyses that were used to screen out unlikely failure modes such as general dry oxidation, general wet oxidation, creep, SCC, etc. For each analysis there will be a description, followed by discussions of uncertainty, validation, data QA, and other views.

3.2.4 Mechanical failure models

This subsection discusses the failure mechanisms and calculation of clad failure rates due to mechanical effects such as rock fall and seismic effects. This section includes uncertainty ranges, validation, abstraction, validation of abstraction, results, data QA, and other views.

3.2.5 Local Corrosion Failure Models

This section describes the failure of clad that may occur due to localized corrosion of the clad. A model will be developed, based primarily on literature data for localized corrosion as a function of in-WP chemistry. The model will include all probable forms of localized corrosion, for example: pitting, crevice. This section will contain a description of each corrosion type, with discussion of uncertainty, validation, abstraction, validation of abstraction, results, data QA, other views.

3.2.6 Hydride-Related Failure Model(s)

This subsection will summarize the processes by which hydrogen may degrade clad performance. It will include a description, and discussion of uncertainty, validation, abstraction, validation of abstraction, results, data QA, and other views.

3.2.7 Dry Unzipping

This subsection will describe the process of clad unzipping that may occur in clad which has a through-wall defect and is exposed to a hot dry air environment, as might occur within a waste package that undergoes juvenile failure. As the fuel inside the clad is oxidized, it expands and may unzip the clad. This section will include a model description, and a discussion of uncertainty, validation, abstraction, validation of abstraction, results, data QA, and other views.

3.2.8 Wet Unzipping

This subsection will summarize the issues and uncertainty of clad unzipping under high humidity conditions. Scenarios will be described that span the range of possible fuel-clad behavior.

Models for the scenarios will be described with discussion of uncertainty, validation, abstraction, validation of abstraction, results, data QA, and other views.

3.2.9 Abstracted Clad Model

This subsection will combine all clad degradation models with the in-WP geochemistry model results to produce history of containment and surface area, which are presented as intermediate results for the various scenarios. From an analyses of the scenarios, two abstracted clad models will be developed: 1) a best estimate for the million year TSPA for the EIS and 2) the best defendable range for the 10,000 year TSPA for the license application. Validity of these abstractions will be discussed along with other views not already discussed.

3.3 CSNF WASTE FORM DEGRADATION

This section will summarize the data and models for commercial fuel degradation.

3.3.1 Discussion Of CSNF Dissolution Data

This subsection will discusses the data, uncertainties, and data QA tracking for all relevant data. It will include: inventory distribution within fuel, flow through experiments, unsaturated Drip Tests, batch tests, electrochemical tests, and natural analogues.

3.3.2 CSNF Dissolution Model

This subsection will describe the selection and derivation of a Q dissolution model, which is a function of In-WP chemistry. This model will be based on the Q flow through experiments. (Note: this process level model is the abstracted model as well) Validation will include discussion of mechanisms and comparison with other Q and non-Q data and other views.

3.3.3 Results

This subsection will combine the CSNF dissolution model with the in-WP geochemistry and clad models to provide intermediate results. Further results will be provided in the In-Package Source Term and Radionuclide transport section.

3.4 DSNF, NAVY, PU DISPOSITION WASTES DEGRADATION

This section will discuss the degradation of all wastes other than CNSF and high level waste glass.

3.4.1 Description

This section will describe each waste group, covering the same issues as covered in 3.1-3.3 for CSNF as applicable, including: special inventory issues such as unusual inventory or inventory distribution, clad or canister degradation models as applicable, waste form degradation including surface area, and other issues specific to the waste form such as pyrophoricity

3.4.2 Uncertainty/Abstraction/Validation/Data QA

This subsection will describe how limited Q data and uncertainty are handled by using bounding abstracted models. It will discuss the validity of the bounding abstractions.

3.4.3 Results

This subsection will present the results from each waste group and comparisons between groups and CSNF. It will address other views.

3.5 HLW GLASS DEGRADATION

This subsection will discuss degradation of high level waste glass, and the model abstraction to be used in TSPA-SR.

3.5.1 Description/Uncertainty

This subsection will describe the processes and uncertainty of degradation of HLW glass in aqueous and vapor phase conditions, including the effects of glass composition, solution chemistry, and a discussion of the surface area undergoing active degradation within a defected pour canister.

3.5.2 Abstracted Degradation Model(s)

This subsection describes the abstraction of above HLW degradation models into one or two models for degradation of glass under aqueous and vapor conditions. It will include a discussion of data QA and validation of abstraction(s), natural analogues and other views.

3.5.3 Results

This subsection will combine the HLW degradation model(s) with the in-WP geochemistry results to produce subsystem results.

3.6 DISSOLVED RADIONUCLIDE CONCENTRATION LIMITS

This subsection summarizes the concentration limits applied at the waste form in the TSPA-SR.

3.6.1 Pure Phase Solubility Models

This subsection summarizes pure phase solubility models as a (In-WP chem.) or distribution as applicable, including models for Tc, I, Np, Pu, U, Se, Pd, Am, Pa, C. It includes description, uncertainty, validation, abstraction, abstraction validation, results, data QA and other views.

3.6.2 Mixed Phase Concentration Limit Models

This subsection describes secondary phase model(s) which provide radionuclide (RN) concentration limits as a function of in-WP chemistry in systems where RN concentrations are controlled by mixed phases. For selected elements, the pure phase solubility range may be extended uncertainty limits or replacing for key elements as deemed appropriate. Description, uncertainty, validation, abstraction, abstraction validation, results, data QA, natural analogues and other views.

3.7 COLLOID-ASSOCIATED RADIONUCLIDE CONCENTRATION LIMITS

This section summarizes the source term for colloid associated radionuclides.

3.7.1 Selection of Isotopes

This subsection describes the selection of isotopes for which colloid assisted transport is important to system performance.

3.7.2 WF Colloid Formation

This section provides the mechanistic basis for WF colloid formation. It includes formation for glass, CSNF, and DSNF derived colloids. (for colloids formed outside the WP see the EBS PMR). This subsection includes a description, mechanistic discussion and uncertainty discussion.

3.7.3 WF Colloid Stability

This section discusses colloid stability and provides a model or a pointer to the model (in the EBS PMR) for colloid concentration as a function of in-WP chemistry. This section will be closely coordinated with the EBS PMR, so that efforts are not duplicated and models are not presented in detail in more than one place. If the EBS colloid concentration model is found to adequately describe the concentration of WF colloids in WP chemistries, this section will have a brief summary of the appropriate EBS PMR section, and justification of why the model is appropriate for WF colloids in the WP as well. If a separate model is required, this will be the location where is it summarized and discussed including, uncertainty, validation, abstraction, and validation of abstraction. The colloid concentration model will be combined with the in-WP chemistry abstraction to obtain colloid concentration results. Data QA and other views will also be discussed.

3.7.4 Attachment/Detachment of Radionuclides to Colloids

This subsection describes the mechanisms and data for attachment/detachment of radionuclides to colloids. Data as well as conceptual model uncertainty will be discussed. Validation issues will be addressed.

3.7.4 Abstraction

This subsection will discuss the abstraction of the data and conceptual models into effective Kd's and irreversible fraction ranges within the TSPA RIP model. Validation and uncertainty in these parameters will be discussed. These parameters, combined with colloid concentration model, in-package chemistry and derived solubilities will be used to obtain the intermediate result of colloidal RN concentration limits. These concentration limits will be compared with observed concentrations from drip and batch tests, and natural/anthropogenic analogues. Data QA and other views will be discussed.

3.8 IN-PACKAGE GEOCHEMISTRY

This section will include a generic in-package geochemistry introduction, description, links to the EBS PMR and the WP PMR, links to other WF processes, uncertainty, and other views.

3.8.1 CSNF Geochemistry

This subsection discusses the in-package chemistry model as a function of the clad abstraction, dissolution rates, flow, etc. Extremes of uncertain parameters such as dissolution rates, flow rates, etc. will be sampled to produce the inputs for a limited number of scenarios. Because the chemistry is a function of the clad model, and the clad localized corrosion model is a function of chemistry, iteration with the clad model may be necessary. After the calculations are run, the results will be inspected for logical binning of results as a function of the inputs. The abstracted chemistry model will be built from these results. A discussion of uncertainty and validation will be included. Data QA and other views will also be included.

3.8.2 Co-Disposal Geochemistry

This subsection discusses the in-package chemistry model as a function of the clad abstraction, dissolution rates (metal, glass, fuel), flow, etc. Extremes of uncertain parameters such as dissolution rates, flow rates, etc. will be sampled to produce the inputs for a limited number of scenarios. Because the chemistry is a function of the other models and these models are in turn a function of chemistry, iteration with other models may be necessary. After the calculations are run, the results will be inspected for logical binning of results as a function of the inputs. The abstracted chemistry model will be built from these results. A discussion of uncertainty and validation will be included. Data QA and other views will also be included.

3.9 IN-PACKAGE SOURCE TERM AND RADIONUCLIDE TRANSPORT ABSTRACTION

This section describes how all the WF models are combined with conceptual models of in-package transport to provide the source term for the TSPA-SR calculations.

3.9.1 Description of In-Package Transport

This subsection includes a description of in-package transport including uncertainty and data QA. Scenarios will be described: flow-through, bathtub, others. Links to WP PMR and EBS PMR will be described. The physical description of WP internals as function of time will be summarized. The fraction of waste in advective versus diffusive pathways as a function of time with links to WP PMR will be discussed. Pathway descriptions as function of time (basket condition, pathway volume, pathway porosity, pathway saturation, pathway connections areas, sorption onto corrosion products will be discussed. Uncertainty and validation will be discussed in each area. Abstraction of in-package transport for 10,000-year license application and 1 million-year EIS TSPA will be discussed.

3.9.2 Integrated Abstracted Model for 10,000 Year License Application

This subsection describes the abstracted models used for the 10,000 year TSPA-SR and TSPA-LA calculations. For processes that continue to have significant uncertainty, but that are relatively less important in the 10,000-year time frame, bounding cases may be adopted. Bounding cases will only be adopted for processes that can not be more realistically modeled and defended as technically correct at this time.

Releases from the waste package will be reported as intermediate results. These releases will be compared to WP releases predicted by others.

3.9.3 Integrated Abstracted Model for 1,000,000 Year EIS Calculations

This subsection describes the abstracted models used for the 1,000,000-year EIS TSPA calculations. For these runs, best estimates will be used for the models.

Releases from the waste package will be reported as intermediate results. The first 10,000 years of these releases will be compared to the releases reported in Section 3.9.2. Releases for the full 1 million-year run will also be reported and compared with other views.

3.10 DATA QUALIFICATION

This section demonstrates the qualification of any data necessary to support use of the model and its sub-models whose qualification has not been demonstrated in the previous sections. Summaries of, and cross-references to, discussions of data pedigrees in AP-3.10Q reports are also provided, as appropriate.

3.11 SUMMARY OF OTHER VIEWS & ALTERNATIVE CONCEPTUAL MODELS

This section documents credible opposing views to the approaches and methods described in the PMR for the model under discussion. The section consists of a relatively brief summary of the opposing view or position, accompanied by an explanation of why the Project does not subscribe to the opposing view or position. To the extent that compensatory measures have been or will be taken to deal with the opposing view, those measures are also described in this section.

The chapter or section also discusses findings of reviewers external to the Project of the models and processes associated with the PMR, and it describes how the findings have been satisfactorily addressed.

CHAPTER 4 RELATIONSHIP WITH THE NUCLEAR REGULATORY COMMISSION (NRC) ISSUE RESOLUTION STATUS REPORTS

Because the NRC has indicated it plans to structure its review of issues that are subjects of PMRs around the NRC's designated Key Technical Issues (KTI) and Issue Resolution Status Reports (IRSR), this chapter of the PMR describes how the acceptance criteria in the IRSRs have been addressed.

4.1 INTRODUCTION

This introductory subsection summarizes the NRC's KTI and IRSR effort. The NRC has determined that resolution of its designated KTIs is crucial to licensing the repository. The NRC staff has issued various IRSRs that describe the status of the KTIs from the NRC's perspective and provide subissues and acceptance criteria. Some of the KTIs may correspond to, or overlap with, the issues and processes that the PMR addresses. This section of the PMR describes how each KTI and its constituent subissues and acceptance criteria have been addressed through the PMR.

Sections below identify the acceptance criteria and discuss how the WF PMR addresses the acceptance criteria. In cases where the WF PMR only partially addresses a given KTI, that fact is noted as appropriate.

4.2 KTI: CONTAINER LIFE AND SOURCE TERM (CLST)

This section lists the CLST acceptance criteria and where the PMR addresses each.

4.2.1 Nine General Acceptance Criteria

This section lists the CLST general acceptance criteria and where the PMR addresses each.

4.2.2 Seven Acceptance Criteria for Subissue 3:

This section addresses the acceptance criteria for Subissue 3: What is the rate of degradation of spent fuel and the rate at which radionuclides in spent fuel are released from the engineered barrier subsystem?

4.2.3 Seven Acceptance Criteria for Subissue 4:

This section addresses the acceptance criteria for Subissue 4: What is the rate of degradation of high-level waste glass and the rate at which radionuclides in high-level waste glass are released from the engineered barrier subsystem?

4.3 KTI: EVOLUTION OF NEAR FIELD ENVIRONMENT (ENFE)

This section lists the ENFE acceptance criteria and where the PMR addresses each.

4.3.1 Subissue 3: Effects of Coupled THC Processes on the Chemical Environment for Radionuclide Release

This section addresses the acceptance criteria for Subissue 3: The effects of coupled THC processes on the chemical environment for radionuclide release. Discussion of acceptance criteria outlined in section 4.3 of the ENFE KTI and identifies where these criteria are addressed in the WF PMR.

4.3.2 Subissue 4: Effects of Coupled THC Processes on Radionuclide Transport Through Engineered and Natural Barriers

This section addresses the acceptance criteria for Subissue 4: The effects of coupled THC processes on radionuclide transport through engineered and natural barriers. Discussion of acceptance criteria outlined in section 4.4 of the ENFE KTI that apply to In-Package transport.

REFERENCES

This chapter contains the complete reference list for the document.

APPENDICES

The appendices contain supporting information deemed appropriate for inclusion in the PMR (if any) but at too great a level of detail for the body of the report.

EBS DEGRADATION, FLOW AND TRANSPORT

PROCESS MODEL REPORT

CHAPTER 1 INTRODUCTION

This chapter provides the "up front" information necessary for the reader to understand the purposes for the report, the basic organization, and related issues. It also supports the reader who desires a quick look at the document without reviewing it in great detail. This chapter also provides a high-level summary of how the EBS PMR relates to technical topics presented in the other PMRs, and other key Project documents such as topical reports, the Environmental Impact Statement (EIS), the Site Recommendation Report (SRR), and the License Application (LA).

1.1 OBJECTIVE

This section describes the objectives of the PMR. Briefly and generically, the objective is to compile a stand-alone report that contains a synthesis of the necessary and sufficient technical information related to the EBS, that the Project will rely on to make its site suitability evaluation, and eventually to support the licensing arguments. The technical information will consist of data, analyses, models, software and supporting documents used to develop the EBS models and defend the applicability of the models for evaluating postclosure performance of the Yucca Mountain repository. The PMR will serve as an important reference for Total System Performance Assessment (TSPA) and key Program milestone documents (EIS, SRR, and LA) and will be written for a readership of knowledgeable persons in technical and regulatory fields. Some of these objectives are common to all the PMRs, and the PMRs together are intended to document all of the necessary and sufficient technical information to support the objectives.

1.2 SCOPE

This section will explain in general terms, the technical information presented in the EBS PMR. It will use graphical features to show the evolution of information from data collection, to TSPA output, and what aspects of the evolution are included in the EBS PMR. The section will also describe where to find relevant subject matter not included in the PMR. References to related discussions in Chapter 2 are provided.

1.3 QUALITY ASSURANCE

This section will explain the quality assurance controls under which the PMR will be developed. The PMR is expected to be designated as quality-affecting through QAP-2-0 analysis. As such the PMR will be developed under AP-3.11Q. This section will also discuss the methods by which non-Q data and references will be incorporated in the PMR, and in specific instances, qualified for direct application in licensing arguments.

For Revision 00 of the EBS PMR, this section will describe how non-Q data referenced in the document will be tracked with "TBVs." This will be only a general discussion, with more specific demonstrations of compliance with tracking requirements to follow in later chapters of the PMR and in the referenced AP-3.10Q modeling and analysis reports.

1.4 RELATIONSHIP TO OTHER PROCESS MODEL REPORTS AND KEY PROJECT DOCUMENTS

This section will discuss how this PMR interfaces with the other PMRs. It will include a list of all the PMRs and a summary-level description of each one. The section will explain how the EBS PMR relates to documents such as the Yucca Mountain Site Description, the Natural Analogs report, the Natural Resources report, topical reports, the SRR, the LA, and other documents as considered applicable and appropriate by the PMR authors. It will also describe the relationship between the subject matter of this PMR and ancillary process models. (This discussion may overlap with some of the information under Section 1.2 above.)

1.5 OVERVIEW DESCRIPTION AND RESULTS OF MODELS AND ABSTRACTION

This section will provide a high-level description of the individual models presented in the PMR, and application of the models to design analyses and TSPA. It will describe the model abstractions, and how the EBS process models are implemented in the overall TSPA model. This section will be a summary of the information that is developed in more detail in Chapter 3 and in the referenced AP-3.10Q reports. The section will also contain a summary of Chapter 4 that integrates the PMR models, abstractions, and analyses. This section is to be provided for the reader who needs an overview of the PMR without examining it in great detail.

CHAPTER 2 EVOLUTION OF THE EBS PROCESS MODELS

This chapter will provide perspective on the background against which the EBS PMR and its support models and documentation have been developed.

2.1 EBS PMR DEVELOPMENT PHILOSOPHY

This section will include an explanation of the philosophy for developing the PMRs, and why this specific PMR has been developed.

2.2 PAST EBS MODELING, ANALYSES AND ABSTRACTIONS

This section will discuss previous treatment of EBS performance in design analyses and TSPA.

2.3 EBS PROCESS MODEL DEVELOPMENT

This chapter will summarize the development of process models and abstractions, starting with the conceptual approach used to develop the models and documentation. It will provide references to parts of Chapter 3 that contain the technical details.

2.4 EBS FEATURES, EVENTS AND PROCESSES

This section will discuss in detail the FEPs that have been screened and analyzed in conjunction with development and application of the EBS process models. The discussion will include the process by which the appropriate FEPs were identified, and the methods used for screening (i.e., for determining whether the FEPs are important to EBS performance). The results of screening will be presented as a list of FEPs for which analysis is required, associated with development and application of the EBS process models.

2.5 EBS BASELINE

This section will describe this most recent baseline engineered configurations and other technical information which affect the EBS PMR. These will include:

- Repository Drift Configuration and Operations
- Waste Head and Radiation Output
- Physical Setting
- Hydrologic Setting
- Geochemical Setting

CHAPTER 3 MODELS AND ABSTRACTIONS

This chapter will identify and introduce the models that are the principal subject of the PMR and describe the relationships among them. The number and types of sub-models, and their applications will be explained.

3.1 MODEL DESCRIPTION

This section will provide in-depth description of the models and sub-models which constitute the EBS PMR, based on AP-3.10Q reports, supporting data, software documentation, and other information from project documents and the open literature. For each principal sub-model, a discussion of alternative conceptual models is provided, and the abstraction process is described.

3.1.1 Water Distribution And Removal

Under some conditions, liquid water will seep into emplacement drifts through fractures in the host rock and move generally downward, potentially contacting waste packages. After waste packages are breached by corrosion, some of this seepage water will contact waste, dissolve or suspend radionuclides, and ultimately carry radionuclides through the EBS to the near-field host rock.

Lateral diversion of liquid water within the drift will occur at the inner drift surface, and more significantly from the operation of engineered structures such as drip shields, capillary barriers, and the outer surface of a penetrated waste package. If most of the seepage flux can be diverted laterally and removed from the drifts before contacting waste, the rates of radionuclide releases from the EBS can be limited, resulting in proportional reduction of dose release at the accessible environment.

This process model will quantify the fraction of liquid water entering the drift that can be prevented from contacting waste by the combined effects of engineered controls on water distribution and removal. The approach must be flexible enough to analyze different design solutions for water diversion, such as drip shields alone, drip shields with backfill, and capillary barriers with or without drip shields. Water can be removed during preclosure operation by evaporation from ventilation, and after closure by drainage into the fractured host rock. Engineered drain holes may be required to assure that adequate drainage survives the thermal pulse.

Processes will include heat transfer by radiation, convection, and conduction, phase changes (vaporization and condensation), and THC coupled processes that may change flow pathways within the EBS. Supporting models will include isothermal and thermally perturbed seepage and THC fracture plugging below the emplacement drifts.

This section will provide in-depth description of the Water Distribution and Removal Model.

3.1.1.1 Water Distribution and Removal model: Discussion of Relevant Data and Data Uncertainties

3.1.1.1.1 Physical/Chemical Characteristics of EBS Materials

3.1.1.1.2 Inputs from Near-Field Environment Process Models

3.1.1.2 Water Distribution and Removal Model Assumptions

3.1.1.3 Water Distribution and Removal Model Description

3.1.1.3.1 Conceptual Model Development

3.1.1.3.1.1 Rationale and Alternative Conceptual Models

3.1.1.3.1.2 Alternative Means for Controlling Water Distribution Within the Drift

3.1.1.3.1.3 Alternative Means for Removing Water From the Drift

3.1.1.3.1.4 Physical and Chemical Environment for Performance of Water Distribution and Removal Subsystems

3.1.1.3.1.5 Performance Measures for Water Distribution and Removal

3.1.1.3.2 Conceptual Design for Water Diversion/Removal Subsystem

3.1.1.3.2.1 Diversion Features

3.1.1.3.2.2 Drainage

3.1.1.3.2.3 THC Effects of Backfill and Invert Materials

3.1.1.3.2.4 Ventilation

3.1.1.3.3.5 Drift Collapse

3.1.1.3.3 Conceptual Description of Effects from Degradation Modes and Coupled Processes

3.1.1.3.3.1 Backfill Degradation

3.1.1.3.3.2 Rockfall

3.1.1.3.3.3 Steel/Corrosion Products

3.1.1.3.3.4 Concrete and Other Cementitious Materials

3.1.1.3.4 Bounding Analyses for Subsystem Performance

3.1.1.3.4.1 Expected Evolution of Water Diversion/Removal Subsystem Performance

3.1.1.3.4.2 Bounding Analysis of Subsystem Degradation Modes and Effects

3.1.1.3.5 Summary of Numerical Model Development and Implementation

3.1.1.3.5.1 Dual-Permeability, Continuum Thermal-Hydrologic Model (NUFT)

3.1.1.3.5.2 Fully Coupled Reactive Transport Model (NUFT-THC)

3.1.1.4 Water Distribution and Removal Model Results

3.1.1.4.1 Calculated Water Distribution and Removal Performance for Baseline Model

3.1.1.4.1.1 Calculated Measures of Water Distribution and Removal Performance

3.1.1.4.1.2 Drift-Wall Benchmark with Near-Field Environment Process Models

3.1.1.4.1.3 Thermal-Hydrologic Conditions at the Surface of the Drip Shield and Waste Package

3.1.1.4.1.4 Waste Package Surface Benchmark with Waste Package Process Models

3.1.1.4.1.5 Sensitivity to Spatial and Temporal Variation of Seepage and Subsystem Degradation Modes

3.1.1.4.1.6 Predicted Flow Rates into Breached Drip Shields and Waste Packages

3.1.1.4.2 Thermal-Hydrologic Processes Within Partially Failed Waste Packages

3.1.1.4.3 Flow Conditions Along Potential Radionuclide Transport Pathways in the EBS

3.1.1.4.3.1 Hydrologic Conditions Along Advective and Diffusive Pathways

3.1.1.4.3.2 Sensitivity to Spatially and Temporally Variable Seepage and Subsystem Degradation Modes

3.1.1.4.3.3 Sensitivity to Drainage Performance

3.1.1.4.4 Sensitivity of Calculated Results to THC Coupled Processes in the EBS

3.1.2 Physical And Chemical Environment Model

The objective of the Physical and Chemical Environment Model is to determine the changes in aqueous chemistry resulting from the interaction of heat and introduced materials with water seeping into the drift, taking into account the variation in seepage and drainage fluxes, the effects of temperature changes on chemical equilibria and rate processes, and physical processes such as evaporation and condensation.

This section will provide in-depth description of the EBS Physical and Chemical Environment Model.

3.1.2.1 Physical And Chemical Environment Model: Discussion Of Relevant Data And Data Uncertainties

3.1.2.1.1 Characterization of Corrosion and Alternation Products for Candidate EBS Materials

3.1.2.1.2 Data on Carbonation and Leaching of Cementitious Materials

3.1.2.1.3 Test Data on Formation and Redissolution of Precipitates

3.1.2.1.4 Test Data on Microbial Interaction with Candidate EBS Materials

3.1.2.1.5 Fluxes from In-Drift Flow Fields (from the EBS Water Distribution and Removal Model)

3.1.2.1.6 TH Conditions at the Drip Shield and Waste Package (from Water Distribution and Removal Model)

3.1.2.1.7 Rockfall Description (from Drift Stability Model)

3.1.2.1.8 Inputs from the Waste Package Degradation and Waste Form Degradation Process Models

3.1.2.1.9 Inputs from the Near-Field Environment Process Models

3.1.2.1.10 Inputs from the Waste Package and EBS Design Organizations

3.1.2.2 Physical And Chemical Environment Model Assumptions

3.1.2.3 Physical And Chemical Environment Model Descriptions

3.1.2.3.1 Conceptual Model Development

3.1.2.3.1.1 Seepage Flux and Composition Cenceptual Basis

3.1.2.3.1.2 Gas-Phase Composition Conceptual Basis

3.1.2.3.1.3 Conceptual Models for Introduced Material Interactions

3.1.2.3.1.4 Conceptual Models for Formation and Redissolution of Precipitates and Salts

3.1.2.3.1.5 Conceptual Models for Thermal-Hydrologic-Chemical Coupled Processes

3.1.2.3.1.6 Conceptual Basis for Estimating Colloid Concentration and Radionuclide Affinities

3.1.2.3.1.7 Conceptual Basis for Analyzing Microbial Interaction with Introduced Materials

3.1.2.3.1.8 Conceptual Basis for Analyzing Rockfall Effects on the EBS and Drip Shields

3.1.2.3.2 Alternative Conceptual Models

3.1.2.3.3 Performance Measures for the Physical/Chemical Environment

3.1.2.3.4 Bounding Analyses for the Physical/Chemical Environment

3.1.2.3.4.1 Bounding Composition for Mobile Water in the EBS

3.1.2.3.4.2 Bounding Model for Occurrence of Precipitates and Salts on the Drip Shield and Waste Package

3.1.2.3.4.3 Bounding Analysis of the Potential for Colloid Transport of Radionuclides in the EBS

3.1.2.3.4.4 Bounding Analysis of Thermal-Hydrologic-Chemical Coupled Process Effects

3.1.2.3.4.5 Bounding Analysis of Rockfall Effects on the EBS and Drip Shield

3.1.2.3.5 Modeling Approaches for the Physical/Chemical Environment

3.1.2.3.5.1 Representation of the EBS by Discrete Cells

3.1.2.3.5.2 Evaluation by Fully Coupled Reactive Transport Modeling

3.1.2.3.5.3 Empirical Approaches to Evaporative Precipitation and Redissolution, Colloid Formation, and Microbial Processes

3.1.2.3.5.4 Mechanical Analysis of Rockfall Effects on EBS and Drip Shield

3.1.2.3.6 Summary of Numerical Model Development and Implementation

3.1.2.3.6.1 EQ3/6

3.1.2.3.6.2 Dual-Permeability TH Model (NUFT)

3.1.2.3.6.3 Fully-Coupled Reactive Transport (NUFT-THC)

3.1.2.3.6.4 Chemical Equilibrium and Reaction/Mass Transfer Models

3.1.2.3.6.5 Structural Analysis fo the Drip Shield (ANSYS)

3.1.2.4 Physical/Chemical Environment Process Model Results

3.1.2.4.1 Model Results for Baseline Model

3.1.2.4.1.1 Drift-Wall Benchmarks with Near-Field Environment Process Models

3.1.2.4.1.2 Physical/Chemical Environment at the Surface of the Drip Shield and Waste Package

3.1.2.4.1.3 Composition of Water Entering Breached Waste Packages

3.1.2.4.1.4 Sensitivity to Spatially and Temporally Variable Seepage

3.1.2.4.1.5 Effects from Rockfall on the Drip Shield

3.1.2.4.1.6 Effects from Other EBS Degradation Modes

3.1.2.4.2 Physical/Chemical Environment Along Potential Transport Pathways in the EBS

3.1.2.4.2.1 Physical and Chemical Environment in the Invert

3.1.2.4.2.2 Sensitivity to Spatially and Temporally Variable Seepage

3.1.2.4.2.3 Sensitivity to EBS Degradation Modes

3.1.2.4.3 Fully-Coupled Reactive Transport Model Results for Baseline Model

3.1.2.4.4 Sensitivity of Calculated Results to THC Coupled Processes in the EBS

3.1.3 EBS Radionuclide Migration Model

This model will provide a description of radionuclide transport within the emplacement drift, as a result of releases from one or more breached waste package. The description will include advective and diffusive transport as well as the potential for retardation due to sorption and precipitation. The analysis will use input from the WP and WF PMRs, and will rely on input from the EBS Water Distribution and Removal Model and the EBS Physical and Chemical Environment Model. Analysis of radionuclide retardation through altered materials, with upstream changes in material characteristics, will be provided for the EBS Degradation Mode Analysis. A model for invert diffusion behavior will be developed using existing analytical information, supplemented by existing and new test data.This analysis will provide input data, including breakthrough curves expressed as transport response to unit releases, to the Near Field Environment and Unsaturated Zone PMRs.

This section will provide in-depth description of the EBS Radionuclide Migration Model.

3.1.3.1 EBS Radionuclide Model: Discussion Of Relevant Data And Data Uncertainties

3.1.3.1.1 EBS Flow Paths and Flow Rates Abstracted from In-Drift Flow Fields

3.1.3.1.2 Physical/Chemical Conditions Along Potential Transport Pathways (from the EBS Physical/Chemical Environment Model)

3.1.3.1.3 Invert/Getter Physical, Hydrologic and Chemical Properties

3.1.3.1.4 Physical, Hydrologic and Chemical Properties of EBS Drainage Features

3.1.3.1.5 Dissolved and Colloidal Radionuclide Releases from Waste Packages (from the WP/WF internal transport model, from WPO)

3.1.3.2 EBS Radionuclide Model Assumptions

3.1.3.3 EBS Radionuclide Model Description

3.1.3.3.1 Conceptual Model Development for EBS Radionuclide Migration

3.1.3.3.1.1 Transport Pathways

3.1.3.3.1.2 Physical and chemical Environment for Transport

3.1.3.3.1.3 Colloidal Transport Processes

3.1.3.3.1.4 Microbially Mediated Transport

3.1.3.3.2 Alternative conceptual Models

3.1.3.3.3 Performance Measures for Radionuclide Transport

3.1.3.3.4 Effects of EBS Degradation Modes and Coupled Processes on Radionuclide Transport

3.1.3.3.5 Bounding Analyses for the Physical/Chemical Environment

3.1.3.3.5.1 Expected Response to a Unity Release from the Waste Package

3.1.3.3.5.2 Bounding Analysis of EBS Degradation Modes and Effects on Radionuclide Migration

3.1.3.3.6 Modeling Approaches for EBS Transport

3.1.3.3.6.1 Representation of the EBS by Discrete Cells for Transport Modeling

3.1.3.3.7 Summary of Numerical Model Development and Implementation

3.1.3.3.7.1 Chemical Equilibrium and Reaction/Mass Transfer Models (EQ3/6)

3.1.3.3.7.2 Fully-Coupled Reactive Transport (NUFT-THC)

3.1.3.4 EBS Radionuclide Migration Model Results

3.1.3.4.1 Network Model Results for Baseline Model

3.1.3.4.1.1 Response at the EBS Boundary, to a Unit Release from the Waste Package

3.1.3.4.1.2 Radionuclide Source Term at the EBS Boundary

3.1.3.4.1.3 Sensitivity to Physical/Chemical Environment Conditions

3.1.3.4.1.4 Sensitivity to Subsystem Degradation Modes

3.1.3.4.1.5 Sensitivity to Conditions Calculated from Fully Coupled Reactive Transport Simulations

3.1.3.4.2 Sensitivity of Calculated Results to THC Coupled Processes in the EBS

3.1.3.4.3 Sensitivity of EBS Releases to Colloidal Processes

3.1.4 EBS Degradation Mode Analysis

This analysis will interactively integrate and reanalyze the FEPs and failure modes that will be investigated within each of the principal EBS models: the Water Distribution and Removal Model, Physical and Chemical Environment Model and EBS Radionuclide Transport Model. For the important FEPs and failure modes, initiating conditions/events will be identified. The analysis will also address coupling among failure modes of the multiple-barrier system, sensitivities to initiating events and the potential effects of coupled degradation modes.

This section identifies the EBS Degradation Mode Analysis and describes how it relates to the EBS PMR.

3.1.4.1 EBS Degradation Mode Analysis: Discussion Of Relevant Data And Data Uncertainties

3.1.4.2 EBS Degradation Mode Analysis Assumptions

3.1.4.3 EBS Degradation Mode Analysis Description

3.1.4.3.1 Potential EBS Degradation Modes and their Effects

3.1.4.3.1.1 Water Diversion/Removal Subsystem

3.1.4.3.1.2 Physical/Chemical Environment

3.1.4.3.1.3 EBS Invert/Getter Subsystem

3.1.4.3.2 Sensitivity to Initiating Events and Degradation Processes

3.1.4.3.2.1 Nature and Rates of Continuous Degradation Processes

3.1.4.3.2.2 Nature and Probability of Disruption by Rock Fall

3.1.4.3.2.3 Nature and Probability of Disruption by Seismic Motion

3.1.4.3.3 Potential Effects from Coupled Degradation Modes

3.1.4.3.3.1 Water diversion/Removal Subsystem

3.1.4.3.3.2 Physical/Chemical Environment with Diversion/Removal Subsystem Degradation

3.1.4.3.3.3 EBS Transport with Diversion/Removal Subsystem Degradation

3.1.4.4 EBS Degradation Mode Analysis Results

3.2 INTEGRATED MODEL DEVELOPMENT

This section describes the approach to developing the model that is the subject of the PMR, consistent with the corresponding AP-3.10Q report(s), including its supporting codes, components, sub-models, and/or analyses. The descriptions include how the sub-models described in the previous subsections are incorporated in the process model. The section describes the development of the conceptual models that form the basis for the process model and describes the development of the model from the conceptual model(s) as described in greater detail in the corresponding AP-3.10Q report(s). Discussions in this section will include summaries of data feeds from AP-3.10Q analyses and reports external to but summarized in this PMR.

3.2.1 Model Uncertainties

This section discusses the uncertainties in the process model that is the topic of this PMR and the assumptions and bases thereof associated with the uncertainties.

3.2.2 Model Validation

This section demonstrates the validity of the model [See Quality Assurance Requirements and Description (DOE/RW-0333P) Glossary and AP-3.10Q for definitions of model validation] and its sub-models and discusses the suitability of the model for its intended application. It includes demonstration of the validity of the data used to support the model validation, as well as demonstration of the validity of the codes that support the models. Results of expert elicitations used to support model validation are included. The discussion summarizes use of natural and man-made analogues in the model validation as appropriate.

3.2.2.1 Water Distribution And Removal Model Validation

3.2.2.1.1 Previous Reported Testing of Diversion and Drainage Concepts

3.2.2.1.2 Laboratory-Scale Tests

3.2.2.1.3 Pilot-Scale Tests

3.2.2.1.4 Ongoing and Planned Tests

3.2.2.2 Physical And Chemical Removal Model Validation

3.2.2.2.1 Testing Introduced Materials for the EBS Environment

3.2.2.2.2 Coupled Process Laboratory Testing at Elevated Temperature

3.2.2.2.3 Ongoing and Planned Tests

3.2.2.3 EBS Radionuclide Migration Removal Model Validation

3.2.2.3.1 Testing Introduced Materials For The EBS Environment

3.2.2.3.2 Coupled Process Laboratory Testing at Elevated Temperature

3.2.2.3.3 Testing of Diffusion Barrier Materials

3.2.2.3.4 Ongoing And Planned Tests

3.2.2.4 EBS Degradation Mode Analysis Validation

3.2.3 Abstraction of the Models

This section describes the method of abstracting the model into the TSPA. Results of expert elicitations and abstraction workshops are included as appropriate. Discussions include any assumptions needed to support the abstraction and descriptions of the approach taken to deal with the uncertainties in the model abstraction process.

3.2.3.1 Water Distribution And Removal Abstraction

3.2.3.1.1 Abstraction of In-Drift Flow Fields

3.2.3.1.2 Abstraction of Thermal-Hydrologic Conditions at the Surface of the Drip Shield and Waste Package

3.2.3.1.3 Flow Rates into Breached Drip Shields and Waste Packages

3.2.3.1.4 Implementation of the In-Drift Flow Fields into the Repository Integration Program (RIP)

3.2.3.2 Physical And Chemical Model Abstraction

3.2.3.2.1 Representation of the Emplacement Drift Environment by Discrete Cells

3.2.3.2.2 In-Drift Geochemical Environment

3.2.3.2.2.1 In-Drift Gas Phase Flux and Composition

3.2.3.2.2.2 Seepage/Backfill Interactions

3.2.3.2.2.3 Occurrence of Precipitates/Salts

3.2.3.2.2.4 Effects from Steel/Corrosion Products

3.2.3.2.2.5 Effects from Cementitious Materials

3.2.3.2.2.6 Influence of the Waste Package and Waste Form on the Chemical Environment

3.2.3.2.2.7 In-Drift Colloid Composition and Concentration

3.2.3.2.2.8 In-Drift Microbial Communities

3.2.3.2.3 Composition of Water Entering Breached Drip Shields and Waste Packages

3.2.3.2.4 Composition of Water Leaving the Waste Package

3.2.3.2.5 Composition of Water Draining From the Emplacement Drift

3.2.3.2.6 Implementation of the In-Drift Geochemical Environment into the Repository Integration Program (RIP)

3.2.3.3 EBS Radionuclide Migration Model Abstraction

3.2.3.3.1 Transport and Water flux Pathways

3.2.3.3.2 Geochemical Conditions along Transport Pathways

3.2.3.3.3 Radionuclide Release from Waste Packages

3.2.3.3.4 Colloid-Facilitated Transport

3.2.3.3.5 Radionuclide Sorption Onto Engineered Materials

3.2.3.3.6 Implementation of EBS Radionuclide Transport into RIP

3.2.3.4 EBS Degradation Mode Analysis Abstraction

3.2.4 Validity of the Abstraction

This section contains a demonstration of the validity of the abstraction. Results of peer reviews or other evaluations of the model abstraction process are included. If the peer reviews or other evaluations were not favorable, cross-references are provided to discussions of such results in Section 4. The discussion summarizes use of natural and man-made analogues in validating the abstraction as appropriate.

This section provides the output of the model and its abstractions; this output provides input to the TSPA analysis.

3.3 DATA QUALIFICATION

This section demonstrates the qualification of any data necessary to support use of the model and its sub-models whose qualification has not been demonstrated in the previous sections. Summaries of, and cross-references to, discussions of data pedigrees in AP-3.10Q reports are also provided, as appropriate.

3.4 SUMMARY OF OTHER VIEWS & ALTERNATIVE CONCEPTUAL MODELS

This section documents credible opposing views to the approaches and methods described in the PMR for the model under discussion. The section consists of a relatively brief summary of the opposing view or position, accompanied by an explanation of why the Project does not subscribe to the opposing view or position. To the extent that compensatory measures have been or will be taken to deal with the opposing view, those measures are also described in this section.

The chapter or section also discusses findings of reviewers external to the Project of the models and processes associated with the PMR, and it describes how the findings have been satisfactorily addressed.

CHAPTER 4 RELATIONSHIP WITH THE NUCLEAR REGULATORY COMMISSION (NRC) ISSUE RESOLUTION STATUS REPORTS

Because the NRC has indicated it plans to structure its review of issues that are subjects of PMRs around the NRC's designated Key Technical Issues (KTI) and Issue Resolution Status Reports (IRSR), this chapter of the PMR describes how the acceptance criteria in the IRSRs have been addressed.

4.1 INTRODUCTION

This introductory subsection summarizes the NRC's KTI and IRSR effort. The NRC has determined that resolution of its designated KTIs is crucial to licensing the repository. The NRC staff has issued various IRSRs that describe the status of the KTIs from the NRC's perspective and provide subissues and acceptance criteria. Some of the KTIs may correspond to, or overlap with, the issues and processes that the PMR addresses. This section of the PMR describes how each KTI and its constituent subissues and acceptance criteria have been addressed through the PMR.

4.2 - 4.X RELATIONSHIP OF PMR TO KTIS

Each of the subsections that follow identifies a Key Technical Issue, its subissues, and associated acceptance criteria that are related to the PMR. The subsections discuss how the PMR addresses the acceptance criteria identified for each subissue of each KTI. In many cases a given PMR only partially addresses a given KTI, and that fact is noted as appropriate.

REFERENCES

This chapter contains the complete reference list for the document.

APPENDICES

The appendices contain supporting information deemed appropriate for inclusion in the PMR (if any) but at too great a level of detail for the body of the report.

BIOSPHERE PROCESS MODEL REPORT (PMR)

CHAPTER 1 INTRODUCTION

This chapter provides summary information on the purpose of the biosphere PMR, its basic organization, regulatory drivers and related issues. This chapter also provides a high-level summary of how the biosphere PMR relates to technical topics presented in the other PMRs (and non-PMRs as appropriate), and key Project documents including topical reports, previous biosphere modeling efforts, the Environmental Impact Statement (EIS), the Site Recommendation Report (SRR), and the License Application (LA).

1.0 INTRODUCTION

Section 1.0 contains introductory text that briefly describes the goal of the Yucca Mountain Project, which is to determine suitability of the Yucca Mountain site for disposal of high-level nuclear waste. If the site is found suitable, the goal is to then seek a license to construct and subsequently to operate and eventually close a high-level waste disposal facility. It goes on to briefly describe the role of the biosphere PMR in meeting those goals. Finally, the section summarizes the layout of the biosphere PMR.

1.1 OBJECTIVE

The objective of the PMR is to develop a model that will describe the movement of radionuclides, released to the environment, to man and to develop biosphere specific dose conversion factors which will allow the dose to an average member of a critical group to be calculated. Part of the objective is to compile in one place, as a stand-alone report, a synthesis of all the necessary and sufficient technical information, related to the development of biosphere–specific dose conversion factors, that the Project will use to support making its site suitability evaluation and ultimately the licensing argument. The technical information consists of data, analyses, models, software and supporting documents used to develop the PMR model (or models) and defends the applicability of the model for its intended purpose of evaluating the movement of radionuclides through the environment during the post-closure phase of the Yucca Mountain repository system.

1.2 SCOPE

This section explains the information presented in and the content of the biosphere PMR. It may use one or more flowcharts to show the evolution of information from data to TSPA output, showing in the flowcharts what parts of the evolution are included in the PMR. The section also describes where to find relevant subject matter not included in the PMR. References to related discussions in Chapter 2 are provided.
Brief summary scope statements for the biosphere PMR is provided below. The scope of the discussions in the biosphere PMR will build on the summary.

Biosphere: The Biosphere PMR addresses the characteristics of the environment that influence the transport of radionuclides to man. It includes a description of the lifestyle and habits of individuals who could be exposed to radioactive material at some time during the postclosure performance period. The PMR describes the reference biosphere, associated pathways and the characteristics of the critical group including location and behavior representative of current conditions, and biosphere transport and uptake parameters used. The PMR also describes information feeds from the SZ Flow and Transport Model and outputs to TSPA.

1.3 QUALITY ASSURANCE

This section explains the quality assurance controls under which the Biosphere PMR has been developed. The Biosphere PMR is expected to be designated as quality-affecting through QAP-2-0 analysis. As such the Biosphere PMR is developed under AP-3.11Q. The section also discusses the method through which non-Q data and references have been upgraded for incorporation in the Biosphere PMR via the constituent models and analyses developed in compliance with AP-3.10Q. In the case of the first version of the Biosphere PMR, discussions include how non-Q data referenced in the document are tracked with "TBVs." This section provides a general discussion, with the more specific demonstrations of compliance with quality assurance requirements to follow in later chapters and to be discussed in the referenced AP-3.10Q analyses.

1.4 RELATIONSHIP TO OTHER PROCESS MODEL REPORTS AND KEY PROJECT DOCUMENTS

This section discusses how the biosphere PMR relates to the Saturated Zone and Transport PMR in terms of interfaces and overlaps. The section explain show the biosphere PMR relates to documents such as topical reports, the SRR, the LA, and other documents as considered applicable and appropriate. It also describes the relationship between the subject matter of this PMR and other contributory or subsequent process models.

1.5 OVERVIEW DESCRIPTION AND RESULTS OF MODELS AND ABSTRACTION

This section provides a description of the models, the abstractions of the models, the results of abstractions, and application of the models in the biosphere PMR. This section summarizes the information that is provided in more detail in Chapter 3 and in the reference AP-3.10Q analyses. The section also contains a summary of Chapter 4 that integrates the PMR models, abstractions, and analyses. The models, sub-models, and abstractions that will be addressed include:

1.5.1 Environmental Transport and Dosimetric Models

GENII-S is a computer code that uses a comprehensive set of environmental pathway models and associated computer programs for estimating potential radiation doses to humans from radionuclides in the environment. It combines multi-pathway environmental transport models with human exposure parameters to calculate radiation doses using methods recommended by the International Commission of Radiation Protection. The model will be described here.

1.5.2 Critical Group Model

Critical group model develops exposure characteristics in terms of consumption rates of groundwater and locally produced food. The conceptual design of a critical group concept is consistent with the recommendations of 10 CFR 63.

1.5.3 Radionuclide Buildup and Removal from Soil Models

Radionuclide buildup in soil will be addressed by developing functional relationships between the values of BDCFs and the duration of irrigation prior to the time point of interest. The functional relationship between the values of BDCFs and the duration of irrigation prior to the time of interest will be developed. Radionuclide removal model will quantify the processes resulting in the depletion of radionuclide concentration in the topsoil. They will include surface soil removal by erosion and radionuclide removal from the topsoil by leaching.

1.5.4 Annual Groundwater Use Model

The annual groundwater usage will be estimated for the community containing the critical group. Usage will be based on current farming practices in the Amargosa Valley. The volumetric usage will be used in the TSPA evaluation to determine the concentration (dilution) of the radionuclides used by the community.

CHAPTER 2 EVOLUTION OF THE BIOSPHERE PROCESS MODEL AND RELATION TO INTEGRATED SITE MODEL

This chapter provides the reasons for which the biosphere PMR is being developed and describes the interrelationship between the biosphere PMR and the Integrated Site model (ISM). The chapter then summarizes the development of the biosphere process model and abstractions by describing the conceptual approach used to develop the process model and abstractions. It provides references to sections of Chapter 3 that contain the descriptions of the technical details associated with the development of the process models and abstractions.

The discussion includes a description of the relationship between the PMR and the constituent sub-process models, abstraction models, and analyses developed under AP

3.10Q. This chapter discusses the data flow and analyses in terms of the document structure (AP-3.10Qs, the PMR itself, and other documents as applicable).

2.1 PREVIOUS BIOSPHERE MODELS AND ASSOCIATED ANALYSES

This section provides a summary of previous biosphere abstractions and the approaches that were taken to model transport of radionuclides to man for the purpose of assessing repository performance. The impact of these previous analyses on the development of the biosphere PMR will also be evaluated.

2.1.1 TSPA-91

The first attempt to model biosphere component of the TSPA and the most comprehensive of the first three TSPA iterations is known as the TSPA-91. It considered a scenario based on exposure to a self-sufficient farmer, who exclusively uses contaminated groundwater for all purposes. This section will describe the scenarios included in the initial TSPS iteration.

2.1.2 TSPA-93 and TSPA-95

Building on the initial assessment of TSPA-91, the two latter TSPA evaluations focused on the process models believed to be major contributors to the uncertainty in the overall TSPA results. These processes of concern did not include the biosphere. The approach based on the methodology prescribed in the national drinking water standard was used to assess doses. This section will describe these subsequent TSPA iterations.

2.1.3 TSPA-VA

TSPA-VA included substantial improvement in biosphere modeling. The approach selected resulted in the generation of probabilistic BDCFs that could be used for RIP input. For the purpose of this assessment the critical group was assumed to be located in Amargosa Valley. This section will give details of this modeling effort.

CHAPTER 3 MODELS AND ABSTRACTIONS

Chapter 3 describes the models, abstractions, and analyses that are discussed in the biosphere PMR. Discussions will include the relationships between the components of Integrated Site Model, and the biosphere model, abstractions, data, and analyses.

3.0 INTRODUCTION

Section 3.0 identifies and introduces the model that is the principal subject of the chapter and shows the relationship among the various components that are discussed in the chapter. The bases for the scopes of sub-models and/or abstractions are explained in terms of the conceptual models. This section also describes the layout of the chapter discussion of those components.

3.1 MODEL DESCRIPTIONS

This section describes the model that is the subject of the PMR consistent with the corresponding AP-3.10Q report, including its supporting code, components, sub-models, and/or analyses. The section summarizes the development of the conceptual model that form the basis for the process model and summarizes the selection of a code that is representative of the process model as described in greater detail in the corresponding AP-3.10Q report. Model requirements will be identified.

3.2 MODEL/CODE JUSTIFICATION

Available codes and capabilities will be reviewed and compared with model requirements. Criteria for selection of the code used to support this PMR will be discussed. Justification for selection of the code will be provided, and it's QA status summarized. Discussions in this section will include descriptions of data feeds from AP-3.10Q analyses and reports external to but summarized in this PMR.

3.2.1 Model Requirements

Of importance is the ability of the code to model, in a comprehensive manner, the multi-pathway exposure scenario that will be considered for the current performance assessment purposes. The component models must address all applicable biosphere FEPs. The issue of capturing of all relevant processes within a complex model will be described in this section.

3.2.2 Available Codes

Description of available codes designed for modeling of environmental transport and performing multi-pathway dose calculations will be given in this section. A comparison of the codes' capabilities will be provided.

3.2.3 Selection Criteria

Criteria for selecting a code capable of modeling environmental transport and calculating doses for the selected scenario will be outlined in this section.

3.2.4 Selection Justification

Individual code's capabilities will be matched against the selection criteria delineated in Section 3.2.3 to justify the selection of a single code to be used in the TSPA analysis.

3.3 GENII-S MODEL

Discussion of the modeling capabilities of the GENII-S code, identification of submodels and their associated functions, and the associated data input requirements.

3.4 DISCUSSION OF UNCERTAINTIES IN THE MODELS

This section discusses the uncertainties associated with the GENII-S model/sub-models and data and bases the uncertainties will be identified. The effect of these uncertainties on the biosphere dose conversion factors will be quantified.

3.4.1 Code uncertainties

This section describes uncertainties associated with the component models within GENII-S. It will include environmental transport model as well as dosimetric models.

3.4.2 Parametric Uncertainties

Uncertainties associated with parametric values will be addressed in this section. The discussion will include the uncertainties associated with the "natural" spread of values a parameter may assume, as well as the range in the assumed parametric values resulting from the inability to quantify them more precisely.

3.5 REFERENCE BIOSPHERES

The reference biospheres and associated scenarios considered within the scope of this PMR will be identified and characterized. For each scenario, significant pathways and radionuclides of interest will be identified. Regulatory requirements and guidance will be discussed

3.5.1 Safety Case (Undisrupted Performance) Scenario

Reference biosphere consistent with 10 CFR 63 will be described in this section. Features, events and processes that describe the reference biosphere will be characteristic of undisrupted performance.

3.5.2 Disruptive Event Scenarios

This section will contain description of reference biosphere for the disruptive event scenario. Biosphere pathways and processes specific to the consideration of disruptive events will be included.

3.6 CRITICAL GROUP

This section will describe the characteristics of the critical group as defined by regulations, the survey conducted in support of the effort to define the characteristics of the critical group, and the characteristics of the average member of that critical group.

3.6.1 Regulatory Definition

Description of the critical group consistent with specifications and intent of 10 CFR 63 will be given in this section.

3.6.2 Survey Objectives, Format and Results

This section will contain description of the food consumption survey in terms of its objective, scope and results. Specifically, the function of the survey to support critical group development will be addressed.

3.6.3 Determination of Critical Group Characteristics

A method of defining empirically-based critical group will be described. It will include an approach used in generating descriptive statistics on the consumption of locally produced food and water.

3.7 ABSTRACTION OF THE MODELS

This section describes the method of abstracting modeling results to consider the build-up of radionuclides in soil and the inclusion into the TSPA. Discussions include any assumptions made to support the abstraction and descriptions of the approach taken to deal with the uncertainties in the model abstraction process.

3.7.1 Overview of Abstraction

This section will discuss the abstraction necessary to allow the RIP code to stochastically sample the BDCFs in a numerically efficient method. The process will include the statistical distributions of the BDCFs and will include the effects of radionuclide build-up in soils due to prolonged irrigation.

3.7.2 Statistical Function Fitting to BDCFs

The stochastic output of the GENII-S code for each radionuclide and predetermined irrigation time will be subjected to a statistical distribution fitting exercise. Although many distributions will be available, the "best fit" distribution will be used and the relevant parameters determined. This information will be passed on to PA for use in RIP after the addition processing reported in the next section.

3.7.3 BDCF Variation as a Function of Irrigation Time

For each given radionuclide, the set of parameters determined in the analyses discussed above will be fitted to an approximate time evolution function. This will generate a set of parameters for each radionuclide, defined to be of interest to TSPA, to allow RIP to stochastically sample over the irrigation time and over the expected uncertainty distribution at that time.

3.7.4 Abstraction Process

The abstraction process reported will use relatively simple spreadsheet analyses. The method of least squares and other goodness of fit criteria to establish appropriated distribution and functional approximation.

3.8 ENVIRONMENTAL TRANSPORT AND DOSIMETRY

This section provides a description of the output of the model (biosphere dose conversion factors) and its sub-models, as well as their abstractions; and describes how these factors are used as input to the TSPA –related and other analyses. For each reference biosphere scenario considered, the results of the output of the model and associated abstractions will be presented and discussed.

3.8.1 Environmental Transport Parameters

This section will discuss the identification and the justification of the data selected to describe the movement of radionuclides in the environment. Environmental transport parameters will be identified, quantified, and the associated ranges discussed. Parameters will be developed for both disruptive and non-disruptive event scenarios.

3.8.2 Transfer Coefficients

This section will discuss and justify the parametric values and associated ranges selected for the transfer coefficients selected for use in calculating the biosphere dose conversion factors. Parametric values will be developed for both disruptive and non-disruptive event scenarios.

3.8.3 Dose Conversion Factors

This section will review the dosimetric model and methodology used in the determination of the dose conversion factors selected for the radionuclides of interest. Dose conversion factors for the radionuclides of interest will be provided.

3.8.4 Pathway Sensitivity Analyses

Pathway sensitivity analysis results in identification of exposure pathways, which result in the highest doses to the receptor. Results of pathway sensitivity analysis will be presented and discussed.

3.8.5 Radionuclide BDCF

This section will describe the outputs of the biosphere modeling, which are BDCFs for individual radionuclides. The results of BDCF calculations will be presented in a summary format and discussed.

3.8.6 Stochastic BDCF Distribution

The process of developing probabilistic distributions of BDCFs will be described in this section. Probabilistic BDCFs will serve as input for RIP.

3.8.7 Parametric Sensitivity Analyses

Description and results of parametric sensitivity analysis will be presented in this section. This analysis is performed to identify parameters, which have the greatest influence on the outcome of BDCF calculations. The results will be given and discussed.

3.8.8 Pathway Sensitivity Analyses

Pathway sensitivity analysis results in identification of exposure pathways, which result in the highest doses to the receptor. Results of pathway sensitivity analysis will be presented and discussed.

3.9 DATA QUALIFICATION

This section reviews the qualification of any data necessary to support use of the model and its sub-models whose qualification has not been demonstrated in the previous sections. Summaries of, and cross-references to, discussions of data pedigrees in AP-3.10Q reports are also provided, as appropriate.

3.9.1 Biosphere Data Qualification Status

Where ever possible, qualified data will be used. Analysis techniques will be developed under the appropriate QA procedure (presently AP3-10Q).

3.9.2 Data Qualification Plan and Schedule

The present plan calls for all data to be qualified during the development of the Biosphere PMR. All QA analyses will be complete before the PMR is issued.

3.11 SUMMARY OF OTHER VIEWS & ALTERNATIVE CONCEPTUAL MODELS

This section documents credible opposing views to the approaches and methods described in the biosphere PMR. The section consists of a relatively brief summary of the opposing view or position, accompanied by an explanation of why the Project does not subscribe to the opposing view or position. To the extent that compensatory measures will be taken to deal with the opposing view, those measures are also described in this section.

The chapter or section also discusses findings and comments of reviewers external to the Project of the models and processes associated with the PMR, and it describes how the findings have been satisfactorily addressed.

CHAPTER 4 RELATIONSHIP WITH THE NUCLEAR REGULATORY COMMISSION (NRC) ISSUE RESOLUTION STATUS REPORTS

Because the NRC has indicated it plans to structure its review of issues that are subjects of PMRs around the NRC's designated Key Technical Issues (KTI) and Issue Resolution Status Reports (IRSR), this chapter of the PMR describes how the acceptance criteria in the IRSRs have been addressed, where applicable.

4.0 INTRODUCTION

This subsection summarizes the NRC's KTI and IRSR effort and the relevant issues/comments related to biosphere modeling activities. The NRC has determined that resolution of its designated KTIs is crucial to licensing the repository. The NRC staff has issued various IRSRs that describe the status of the KTIs from the NRC's perspective and provide subissues and acceptance criteria. This section of the PMR describes how each KTI and its constituent subissues and acceptance criteria have been addressed through the PMR. In addition to the KTIs, issues from other reviews, such as those from the Peer Review Panel and the Nuclear Waste Technical Review Board will be reviewed, summarized and resolutions of those issues will be presented.

4.2 THROUGH 4.X RELATIONSHIP OF PMR TO KTIS

Each subsection that follows identifies a Key Technical Issue, its sub-issues, and associated acceptance criteria that are related to the biosphere PMR. The subsections discuss how the PMR addresses the acceptance criteria identified for each sub-issue of each KTI. In many cases a given PMR only partially addresses a given KTI, and that fact is noted as appropriate. Other subsections will discuss the resolution of issues identified as a result of other peer reviews.

REFERENCES

This chapter contains the complete reference list for the document.

APPENDICES

The appendices contain supporting information deemed appropriate for inclusion in the PMR.

TECTONIC HAZARDS PROCESS MODEL REPORT

CHAPTER 1.0 INTRODUCTION

This report will summarize the results of analyses addressing the consequences of volcanic and seismic events that may affect the postclosure performance of a geologic repository at Yucca Mountain, Nevada. These consequences will be abstracted to provide inputs for an assessment of the long-term performance of a repository in protecting the health and safety of the public.

1.0 INTRODUCTION

Introductory text will briefly describe the goals of the Yucca Mountain Project. The section will indicate that the report contributes to meeting these goals by documenting inputs resulting from tectonic disruptive events to the assessment of total system performance.

The section will also describe the organization of the report.

1.1 OBJECTIVE

This section will describe the objective of the report to summarize information on the consequences of volcanic and seismic events that feed into an assessment of the postclosure performance of a geologic repository at Yucca Mountain. Hazard analyses provide information on the frequency of occurrence and spatial distribution of tectonic events, but do not address the consequences of the igneous and seismic events. This report is intended to provide the link between the hazard analyses and the needs of performance assessment.

1.2 SCOPE

The scope of the report is to summarize the consequences of volcanic and seismic events that potentially could affect a geologic repository at Yucca Mountain. The consequence analyses will rely on inputs from the probabilistic volcanic and probabilistic seismic hazard analyses to describe the frequency of disruptive events. Effects of igneous activity on drifts, waste packages, and waste forms will be addressed. Modes of radionuclide release resulting from igneous events will also be characterized. Incremental effects of seismic ground motion on rockfall will be described. The consequences of fault displacement for the engineered barrier system and waste packages will be summarized. Finally, the potential effects of volcanic and seismic activity on the hydrologic system will be discussed.

Results of the probabilistic volcanic and seismic hazard analyses will be briefly discussed in Chapter 2, but will not be presented in detail. Emphasis will be on how, as part of the characterization of uncertainty, alternative models of volcanic and seismic sources are incorporated into the results.

This section will also summarize how the information presented relates to key technical issues identified by the U.S. Nuclear Regulatory Commission (NRC). Cross references to discussions in Chapter 4 that present additional detail will also be provided.

Disruptive events that are not tectonic in origin (i.e., criticality, human intrusion) will not be covered in this report.

1.3 QUALITY ASSURANCE

This section explains the quality assurance controls under which the report has been developed. A QAP-2-0 analysis is expected to identify report preparation as quality-affecting work. The report will be developed under AP-3.11Q. Tracking of non-Q data as to-be-verified (TBV) will be discussed for those non-Q data that are relied upon for analyses related to safety.

1.4 RELATIONSHIP TO PROCESS MODEL REPORTS AND KEY PROJECT DOCUMENTS

This section will describe how this report relates to other key project documents, including the Environmental Impact Statement, the Site Recommendation, and the License Application. Interfaces with process model reports on waste package degradation; EBS degradation, flow and transport; unsaturated zone flow and transport; and saturated zone flow and transport will be addressed. The relation of this report to the probabilistic volcanic and seismic hazard analyses will also be discussed. This section will further explain how this report relates to preclosure seismic design and topical reports on seismic issues. Preclosure seismic issues are not the subject of this report.

1.5 OVERVIEW DESCRIPTION AND RESULTS OF MODELS AND ABSTRACTION

This section provides a high-level description of the models, the abstractions of the models, the results of abstractions, and application of the models in the report. This section summarizes the information that is provided in more detail in Chapter 3 and in much greater detail in the reference AP-3.10Q analyses. The section is intended to support the reader who wants to get the gist of the report without examining it in great detail.

CHAPTER 2.0 PREVIOUS WORK RELATED TO DISRUPTIVE EVENTS

This chapter provides perspective on the background against which the analyses of the consequences of disruptive events are being developed. It includes an explanation of the philosophy for developing the report. It will explain the flow from data collection and analyses through hazard assessment to consequences and eventually to impacts on the performance of a geologic repository at Yucca Mountain.

2.1 TECTONIC SETTING

At a fairly high level, this section will present the tectonic setting of Yucca Mountain. It will briefly describe the tectonic elements of the site region and their evolution over the past 10 to 15 million years. It will note various tectonic models that have been proposed for the site region. The section will establish the context for considering tectonic hazards in the design and assessment of performance for a geologic repository at Yucca Mountain.

2.2 STUDIES OF VOLCANIC AND IGNEOUS PROCESSES AT YUCCA MOUNTAIN

This section will summarize the results of site characterization studies of volcanic and igneous processes at Yucca Mountain. At a fairly high level, it will describe the current understanding of the volcanic framework of the Yucca Mountain vicinity as it relates to interpretations that feed the probabilistic volcanic hazard assessment. Uncertainty in characterizing the inputs will also be addressed, including interpretations by those outside the project.

2.3 PROBABILISTIC VOLCANIC HAZARD ANALYSIS

This section will summarize the process and results of the probabilistic volcanic hazard analysis for Yucca Mountain. The discussion will note that the analysis incorporates differing interpretations of volcanic source zones and recurrence. Results are expressed as the annual frequency of intersection of the repository footprint by a volcanic event.

2.4 STUDIES OF SEISMIC PROCESSES AT YUCCA MOUNTAIN

This section will summarize the results of site characterization studies of seismic processes at Yucca Mountain. At a fairly high level, it will describe the current understanding of the seismologic framework of the Yucca Mountain vicinity as it relates to interpretations of seismic source zones, earthquake magnitudes, earthquake recurrence, characterizing the inputs will also be addressed, including interpretations by those outside the project. This section will also summarize the characteristics of faults that might be subject to displacement within or adjacent to the repository area.

2.5 PROBABILISTIC SEISMIC HAZARD ANALYSES

This section will summarize the process and results of the probabilistic seismic hazard analyses for Yucca Mountain. The discussion will note that the analyses incorporate differing interpretations of seismic source zones, earthquake magnitude, earthquake recurrence, surface fault displacement, and earthquake ground motion. Results for ground motion are expressed as the annual frequency with which different levels of acceleration and velocity will be exceeded. Results for fault displacement are expressed as the annual frequency with which different amounts of fault displacement will be exceeded.

2.6 CONSEQUENCE ANALYSES FOR TECTONIC DISRUPTIVE EVENTS

This section will describe the approach to modeling the consequences of tectonic events for performance assessment. It will discuss how the consequences have been addressed in past assessments of postclosure performance and how those approaches will be updated or modified for the current effort.

2.7 FEATURES, EVENTS AND PROCESSES ASSOCIATED WITH TECTONIC DISRUPTIVE EVENTS

This chapter will discuss the features, events, and processes (FEPs) related to tectonic processes. The discussion will include the rationale for including and excluding the FEPs from further analysis.

CHAPTER 3.0 MODELS AND ABSTRACTIONS

Chapter 3 describes the models, analyses, and abstractions that represent the consequences of tectonic disruptive events for input to assessment of postclosure performance.

Analyses will address the consequences of both volcanic and seismic events. Conceptual models of igneous activity and eruption will feed analyses describing the effects of igneous activity on repository structures, waste packages, and the waste form. Analyses will also address how waste is entrained in ascending magma and dispersed in an eruption. For seismic activity, conceptual models will describe how ground motion and fault displacement affect drift stability and the hydrologic regime. These models will feed analyses of consequent damage to the engineered barrier system, the waste package, and the waste form.

3.1 CONSEQUENCES OF IGNEOUS ACTIVITY

This section will describe the analyses of igneous activity effects. Analyses will address the spatial distribution of dikes and eruptive vents, the interaction of drifts with erupting magma, the behavior of waste packages and waste forms in the presence of magma, and the dispersal and deposition of erupted igneous material.

3.1.1 Characterization of volcanic eruptions through Yucca Mountain

This section will describe the lengths, widths, orientations, temperatures, and chemical characteristics of dikes intruding into the repository. In addition it will address the number of eruptive vents within the repository footprint, given dike intersection.

3.1.1.1 Approach

3.1.1.2 Data and uncertainties

3.1.1.3 Assumptions

3.1.1.4 Results

3.1.2 Magma-Repository Drift Interactions

This section will describe the likely paths taken by ascending magma as it interacts with the repository. It will also describe the evolution of eruptive conduits and the fragmentation behavior as the magma moves through the repository and erupts into the atmosphere.

3.1.2.1 Approach

3.1.2.2 Data and uncertainties

3.1.2.3 Assumptions

3.1.2.4 Results

3.1.3 Contact of Waste Packages by Magma

Using information on the layout of the repository and the likely distribution of intruding dikes and eruptive vents, this section will describe the number of waste packages potentially contacted by magma during the intrusion of a dike.

3.1.3.1 Approach

3.1.3.2 Data and uncertainties

3.1.3.3 Assumptions

3.1.3.4 Results

3.1.4 Waste Package Behavior in the Presence of Magma

This section will describe the interaction between a waste package and surrounding magma. The joint evolution of the magma-waste package physical and chemical systems will be presented to examine the potential for accelerated waste package failure. PDFs for magma-induced waste package failures will be developed.

3.1.4.1 Approach

3.1.4.2 Data and uncertainties

3.1.4.3 Assumptions

3.1.4.4 Results

3.1.5 Waste Form Behavior in the Presence of Magma

This section will describe the interaction between a waste form and surrounding magma. The joint evolution of the magma-waste form physical and chemical systems will be presented. PDFs will be developed to describe the range of particle sizes resulting from waste form interaction with erupting magma.

3.1.5.1 Approach

3.1.5.2 Data and uncertainties

3.1.5.3 Assumptions

3.1.5.4 Results

3.1.6 Eruption and Dispersal of Magma Entrained Waste

This section will describe PDFs developed to characterize the range of particle sizes as a function of magma ascent velocities and the amount of radioactive material likely to be released. This section will also discuss the height, volume, duration of various phases, exit velocity, and ash particle characteristics. In addition, the section will address the dispersal of radioactive material in an ash plume.

3.1.6.1 Approach

3.1.6.2 Data and uncertainties

3.1.6.3 Assumptions

3.1.6.4 Results

3.1.7 Ash Deposition and Subsequent Dose

This section will describe the amount of ash and entrained radioactive waste that would be deposited at a designated receptor site(s). It will also describe the characteristics of the ash deposit. It will discuss various dose pathways to receptors. In addition, it will address geologic processes that could modify the ash deposit. Biosphere dose conversion factors will be described.

3.1.7.1 Approach

3.1.7.2 Data and uncertainties

3.1.7.3 Assumptions

3.1.7.4 Results

3.1.8 Summary of Volcanic Effects

This section will summarize the potential effects of a dike intruding the repository and erupting at the surface after causing waste packages to be breached and entrainment of released radioactive material. The section will also summarize the potential dose resulting from deposited volcanic ash.

3.2 CONSEQUENCES OF SEISMIC EVENTS

This section will describe the analyses of effects of vibratory ground motion and fault displacement. Analyses will address the incremental effect of ground motion on rockfall; the effect of seismic-induced rockfall on waste package behavior; how ground motion affects the waste form; behavior of the drift, engineered barrier system, waste package, and waste form if fault displacement intersects a drift; and how seismic effects on the hydrologic regime are addressed.

3.2.1 Drift Effects from Ground Motion

This section will summarize the incremental effect from seismic ground motion on rockfall in the waste emplacement drifts. Information on the frequency of occurrence of different levels for ground motion and the distribution of sizes of blocks that could be dislodged will be used to determine the distribution of seismic induced rockfall.

3.2.1.1 Approach

3.2.1.2 Data and uncertainties

3.2.1.3 Assumptions

3.2.1.4 Results

3.2.2 Waste Package Damage from Seismic-Induced Rockfall

This section will summarize the incremental impact of seismic-induced rockfall on the degradation of waste packages. It will describe the ability of rockfall blocks of different size to damage or breach a waste package. It will address the impact of multiple rockfall events on a single waste package.

3.2.2.1 Approach

3.2.2.2 Data and uncertainties

3.2.2.3 Assumptions

3.2.2.4 Results

3.2.3 Waste Form Effects from Ground Motion

This section will describe the effects of vibratory ground motion on waste form cladding and any other affected waste form characteristics.

3.2.3.1 Approach

3.2.3.2 Data and uncertainties

3.2.3.3 Assumptions

3.2.3.4 Results

3.2.4 Repository Effects from Fault Displacement

This section describes analyses that address the effects on the drift, engineered barrier system, waste package, and waste form from fault displacement. It will discuss changes in the characteristics of fractures in the vicinity of faulting that might affect rock permeability.

3.2.4.1 Approach

3.2.4.2 Data and uncertainties

3.2.4.3 Assumptions

3.2.4.4 Results

3.2.5 Hydrologic Effects of Fault Displacement

This section will describe an analysis of the hydrologic effects of fault displacement. The analysis will address the potential for fault displacement to affect the hydrologic properties of the site, create perched water bodies, or otherwise alter the characteristics of the unsaturated or saturated zone.

3.2.5.1 Approach

3.2.5.2 Data and uncertainties

3.2.5.3 Assumptions

3.2.5.4 Results

3.2.6 Summary of Seismic Effects

This section will summarize the effects of vibratory ground motion and fault displacement on the drift, engineered barrier system components, the waste package, and waste forms. In addition, the section will summarize seismic effects on the natural system, such as changes in hydrologic properties.

3.3 ABSTRACTION OF THE MODELS

This section describes the method of abstracting the consequences of tectonic events into the TSPA. Discussions include any assumptions needed to support the abstraction and descriptions of the approach taken to deal with the uncertainties in the model abstraction process.

3.4 VALIDITY OF THE ABSTRACTION

This section contains a demonstration of the validity of the abstraction. Results of peer reviews or other evaluations of the model abstraction process are included. The discussion summarizes use of natural and man-made analogs in validating the abstraction, as appropriate.

3.5 DATA QUALIFICATION

This section demonstrates the qualification of any data necessary to support use of the model and its sub-models whose qualification has not been demonstrated in the previous sections. Summaries of, and cross-references to, discussions of data pedigrees in AP-3.10Q reports are also provided, as appropriate.

3.6 SUMMARY OF OTHER VIEWS & ALTERNATIVE CONCEPTUAL MODELS

This section documents credible alternative views to the approaches and methods used to model and describe the effects of seismic and volcanic events on a geologic repository at Yucca Mountain. (Alternate interpretations affecting the volcanic and seismic hazard at the site are documented in the PVHA and PSHA reports and are addressed in Section 2.) For each alternative view, if any, the section will provide a relatively brief summary of the view or position, accompanied by an explanation of why the Project does not subscribe to the view or position. To the extent that compensatory measures have been or will be taken to deal with the alternative view, those measures are also described in this section.

This section will also discuss findings of reviewers external to the Project, if any, that are relevant to the analyses described and summarized in this report. The section will describe how any such findings have been satisfactorily addressed.

CHAPTER 4.0 IMPLICATIONS FOR ADDRESSING NRC KEY TECHNICAL ISSUES

This chapter will describe how the results of tectonic events' analyses help to address the key technical issues that have been identified by the Nuclear Regulatory Commission and described in their Issue Resolution Status Reports. Key technical issues of interest to this report are Igneous Activity, Structural Deformation and Seismicity, Container Life and Source Term, Repository Design and Thermal-Mechanical Effects, Total System Performance Assessment and Integration, and Unsaturated and Saturated Zone Flow Under Isothermal Conditions.

4.1 INTRODUCTION

This section summarizes the NRC's KTI and IRSR effort. The NRC has determined that resolution of its designated KTIs is crucial to licensing the repository. The NRC staff has issued various IRSRs that describe the status of the KTIs from the NRC's perspective and provide subissues and acceptance criteria.

4.2 IGNEOUS ACTIVITY

This section will describe how the results of analyses of the consequences of volcanic events affecting the repository address subissues and acceptance criteria of the Igneous Activity key technical issue.

4.3 STRUCTURAL DEFORMATION AND SEISMICITY

This section will describe how the results of analyses of the consequences of seismic events affecting the repository address subissues and acceptance criteria of the Structural Deformation and Seismicity key technical issue.

4.4 CONTAINER LIFE AND SOURCE TERM

This section will describe how the results of analyses of the consequences of volcanic and seismic events address subissues and acceptance criteria of the Container Life and Source Term key technical issue.

4.5 REPOSITORY DESIGN AND THERMAL-MECHANICAL EFFECTS

This section will describe how the results of analyses of the consequences of volcanic and seismic events address subissues and acceptance criteria of the Repository Design and Thermal-Mechanical Effects key technical issue.

4.6 TOTAL SYSTEM PERFORMANCE ASSESSMENT AND INTEGRATION

This section will describe how the results of analyses of the consequences of volcanic and seismic events address subissues and acceptance criteria of the Total System Performance Assessment and Integration key technical issue.

4.7 UNSATURATED AND SATURATED ZONE FLOW UNDER ISOTHERMAL CONDITIONS

This section will describe how the results of analyses of the consequences of volcanic and seismic events address subissues and acceptance criteria of the Unsaturated and Saturated Zone Flow Under Isothermal Conditions key technical issue.

REFERENCES

This chapter contains the complete reference list for the document.

APPENDICES

The appendices (if any) will contain supporting information deemed appropriate for inclusion in the report but at too great a level of detail for the body of the report.

AP-3.10Q Report Scope Statements

1) c) iv)

			ANALYSIS AND MODEL REPORTS SUPPORTING THE INTEGRATED SITE MODEL PMR	
			Title	**Resp. Org.**
		1	Rock Properties Model	NEPO
		2	Geologic Framework Model	NEPO
		3	Mineralogical Model	NEPO
		4	Stratigraphic Workbooks	NEPO

Analysis and Model Reports Supporting the Integrated Site Model

1) Rock Properties Model Report SPP5830

Description: The Rock Property Model produces three-dimensional sets of heterogeneous numerical models of selected rock properties: porosity, bulk density, matrix saturated hydraulic conductivity, and thermal conductivity. This modeling is performed using GSLIB version 2.0. Geostatistical techniques are used to approximate the real world variability of the rock properties within the GFM grid volume. The heterogeneous material property distributions that exist in unsampled locations are predicted based on the distributions and statistical character of the measured data. The uncertainty associated with the prediction of rock property values for the unsampled locations may then be assessed as it is propagated in downstream process models. The data inputs to the Rock Property Model are computed petrophysical porosity, laboratory core porosity measurements, porosity derived secondary (surrogate) properties, and XRD mineralogical data. Results from the Rock Property Model are used to confirm and corroborate input values for the Unsaturated and Saturated Zone Flow and Transport Models.

Input Data: Borehole Porosity AP-3.10Q, Quantitative X-ray Diffraction Mineralogical Analysis, Rock Properties Analysis of borehole core samples

Feeds to: Integrated Site Model AP-3.10Q

Responsible Organization: NEPO

Due Date: July 29, 1999

2) Geologic Framework Model AP-3.10Q SPP5820

Description: The Geologic Framework Model creates a three dimensional geologic model which displays isochore layers of the stratigraphic units and faults. This model is constructed using Earthvision version 4.0. After the initial construction the model undergoes repeated assessment and examination to ensure that the final output is consistent and geologically reasonable. A "minimum tension" algorithm is used to construct the model because it provides a robust natural surface through the scattered data points. Data inputs to the Geologic Framework Model are: borehole lithostratigraphic contacts, geologic and topographic maps, measured stratigraphic sections and geophysical data. Results from the Geologic Framework Model are used to confirm and validate the structural grids developed for the Unsaturated and Saturated Zone Flow and

Transport Models. It is also used by Repository Design as the reference for locating the proposed repository and situating exploratory drifts and niches.

Input Data: Geologic Map; Borehole lithostratigraphic contacts; ESF Geologic Contacts; Measured geologic sections; Paleozoic surface contact; Surface topography

Feeds to: Rock Properties Model AP-3.10Q; Mineralogical Model AP-3.10Q; Integrated Site Model AP-3.10Q

Responsible Organization: NEPO.

Due Date: May 21, 1999

3) Mineralogical Model AP-3.10Q SPP5840

Description: The Mineralogical Model was developed to provide a complete description of the mineralogical content of rocks at Yucca Mountain. Modeling is based on the software Stratamodel and RC^2. Stratamodel conducts weighted interpolations of drill hole data within stratigraphic units to produce a volumentric distribution of the mineralogy. Geostatistical investigations were conducted using RC^2 which were used to provide estimates of mineralogical uncertainty and characterize zeolite distributions. The Mineralogical Model is developed from quantitative X-ray diffraction (XRD) analysis of core and cuttings from boreholes. This model of mineral distributions can serve as the basis for performing radionuclide transport studies, reactive transport calculations, and mineral reaction modeling.

Input Data: Quantitative X-ray diffraction mineralogical analysis of core; Geologic Framework Model

Feeds to: Integrated Site Model

Responsible Organization: NEPO

Due Date: July 22, 1999

4) Stratigraphic Workbooks AP-3.10Q (SPP5806)

The Stratigraphic Workbook provides the technical documentation of the stratigraphic contacts used to construct the GFM and UZ and SZ Flow and Transport Grids. 82 boreholes are documented. Each borehole is captured in an Excel Spreadsheet. The spreadsheets contain an integrated presentation of: available data, prioritization of the data used to define the contacts (directly relied upon versus corroborative), text describing the basis for placing the contacts, and estimates on the reliability of the contact placement. It also contains graphs that display the location of the contacts relative to geophysical logs and density analysis of core samples.

Input data: Borehole geophysical logs; Rock Properties Analysis of borehole core samples; Quantitative XRD Mineralogy; Core Samples; Cuttings Samples; Rock Samples; Borehole Video; Core Video; Core Photographs; Maps

Feeds to: Geologic Framework Model; UZ Flow and Transport ISM; SZ Flow and Transport ISM

Responsible: NEPO

Due Date: Oct 01, 1999

			ANALYSIS AND MODEL REPORTS SUPPORTING THE UZ FLOW AND TRANSPORT MODEL PMR	
			Title	Resp. Org.
		1	Conceptual & Numerical Models for UZ Flow and Transport	NEPO
		2	Features, Events, and Processes – FEPs	PAO
		3	Climate Model	NEPO
		4	Infiltration Model	NEPO
		5	Analysis of Fracture and Matrix Properties Data	NEPO
		6	Hydrologic Properties from In Site Field Testing	NEPO
		7	Fracture Properties from Vertical Boreholes and Alcove Testing	NEPO
		8	Alcove and Moisture Testing	NEPO
		9	Ambient Geochemistry Data	NEPO
		10	Ambient Geochemistry Data	NEPO
		11	Transport Properties	NEPO
		12	Transport Properties from Busted Butte UZTT	NEPO
		13	Enhanced Colloid Transport	NEPO
		14	Development of the 3D UZ Site Scale Model Grid	NEPO
		15	1-D Inversion Calibrated Properties Model	NEPO
		16	Calibrated Properties Model	NEPO
		17	Analysis Comparing Advection-Dispersion Transport Solution and Particle Tracking	PAO
		18	UZ Submodels for Hydrogeologic Units	NEPO
		19	UZ Submodels for Flow Processes	NEPO
		20	Base Case Flow Fields for the UZ	NEPO
		21	Radionuclide Transport Models Under Ambient and Thermal Conditions	NEPO
		22	Mountain-Scale Coupled Processes (TH, THC, THM) Models	NEPO
		23	Seepage Calibration Model and Seepage Testing Data	NEPO
		24	Drift-Scale Coupled Processes	NEPO
		25	Seepage Models for PA Including Drift Collapse and Drainage of Rocks Below the Drift	NEPO
		26	Analysis of Infiltration Uncertainty	NEPO
		27	Abstraction of Flow Fields for RIP	PAO
		28	Abstraction of Coupled Processes (TH, THC, & THM) into Flow Fields	PAO
		29	Abstraction of Drift Seepage and Drift-Scale Coupled Processes (TH, THC and THM)	PAO
		30	Particle Tracking Model and Abstraction of Transport Processes (including colloids, decay, diffusion, etc.)	PAO

			ANALYSIS AND MODEL REPORTS SUPPORTING THE UZ FLOW AND TRANSPORT MODEL PMR	
			Title	Resp. Org.
		31	UZ Model Validation Activities	NEPO
		32	Natural Analogs	NEPO
		33	Geostatistical Representation of CHn Formation	NEPO
		34	Analysis of Base-Case Particle Tracking Results of the Base-Case Flow Fields	PAO
		35	Sensitivity Studies for Site-Scale UZ Flow, Seepage into Drifts, and Site-Scale UZ Transport	PAO

Analysis and Model Reports Supporting the UZ Flow and Transport PMR

1) Conceptual & Numerical Models for UZ Flow and Transport (U1090)

Description: Analysis describing the conceptual and numerical modeling approaches for flow and transport in fractured, unsaturated rock. Conceptual models include those for fracture and matrix components of flow and transport, fracture/matrix interaction, perched water, effects of major faults, effects of coupled processes, radionuclide transport, transient flow, flow focusing processes, effects of fracture and matrix heterogeneities, and gas flow processes. Numerical modeling approaches include continuum approaches (ECM, dual permeability, MINC, and dual porosity), discrete fracture approaches, fracture network approaches, particle tracking, and fully coupled advective-dispersion approaches. This report also documents the Active Fracture Model alternative conceptualization.

Input Data: N/A

Feeds to: UZ Submodels for Hydrogeologic Units [U3000]
UZ Submodels for Flow Processes [U3030]
UZ PMR

Responsible Organization: NEPO

Due Date for Rev00A: 7/30/99

2) Features, Events, and Processes - FEPs (U7080)

Description: Discussion of FEPs not included in other AP-3.10Q reports. Also provides a summary list FEPs and identifies which AP-3.10Q reports these issues are addressed.

Input Data: TBD

Feeds to: UZ PMR

Responsible Organization: PAO

Due Date for Rev00A: 7/30/99

3) **Climate Model (U1020)**

Description: This report documents the historical climate changes at Yucca Mountain as well as the estimated conditions for postulated future climate states during the next 10,000 years. Three potential future climates, a modern-like, a monsoon, and a glacial transition climate were identified. The characteristics of the three climates includes their duration, 600, 1400, and 8000 years respectively, and the properties of each climate as obtained from meteorologic stations whose values, for example, of mean annual precipitation and temperature are believed to approximate the future climates range of values. The data provides input parameters for the infiltration model and PA.

Input Data: Precipitation and temperature data from meteorological stations (outside the YM area)

Feeds to: PA
Infiltration Model [U1030]
UZ PMR

Responsible Organization: NEPO

Due Date for Rev00A: 5/31/99

4) **Infiltration Model (U1030)**

Description: This report documents the 1999 Infiltration Model. It includes an enhanced description of precipitation and soil moisture processes at Yucca Mountain. It also includes process descriptions for snowmelt and surface water infiltration during intermittent flow in washes. The geologic map of rock and soil cover has been revised based on the work of Day and Warren. The reevaluation of the precipitation record is discussed and used to estimate the average rate under current conditions and calculate the percolation rate. The effects of El Nino events are considered by appropriate weighting of their frequency. Percolation rates for wetter conditions are estimated by considering increased precipitation. These future climates include the long-term average and a super pluvial period. The spatial distribution of percolation for each assumed precipitation rate is provided as well as process descriptions.

Input Data: Surface geological maps
Rainfall data from stations at NTS and YM
Estimated precipitation for future climates from Climate Model [U1020]

Feeds to: PA

Analysis of Infiltration Uncertainty [U4060]
Base Case Flow Fields for the UZ [U7000]
1-D Inversion Calibrated Properties Model [U2000]
Calibrated Properties Model [U2010]
UZ Submodels for Hydrogeologic Units [U3000]
UZ Submodels for Flow Processes [U3030]
Mountain-Scale Coupled Processes Models [U5000]
UZ PMR

Responsible Organization: NEPO

Due Date for Rev00A: 5/31/99

5) **Analysis of Fracture and Matrix Properties Data (U4040)**

Description: This report describes the analysis performed to determine fracture and matrix properties for the UZ Model layers based on field data. It includes all computation methods, assumptions, and analogues used to generate this base case non-calibrated property set. These properties are used as input to the Calibration Properties Model for further refinement. The fracture properties estimated include fracture permeability, frequency, aperture, porosity, and van Genuchten fitted parameters. The data sources include the detailed line survey (DLS) in the Exploratory Studies Facility (ESF) North Ramp, Main Drift, South Ramp and Cross Drift and air-injection testing data from vertical boreholes, the Upper Tiva Canyon, Bow Ridge Fault, and Upper Paintbrush Contact Alcoves, the Single Heater Test area, and the Drift Scale Test area. The matrix properties estimated include the average porosity, average saturation, geometric mean for saturated hydraulic conductivity and matrix permeability, and the van Genuchten α_m and m parameters. These values are based on measured core samples collected and analyzed by the USGS. Thermal properties for each UZ Model are also provided.

Input Data: DLS data from the ESF North and South Ramp, Main Drift, and Cross Drift.
Air-injection testing data from vertical boreholes, the Upper Tiva Canyon, Bow Ridge Fault, and Upper Paintbrush Contact Alcoves, the SHT area, and the DST area [U1070]
Measured properties from core samples - effective porosity, bulk density, porosity, particle density, volumetric water content, saturation, water potential, saturated hydraulic conductivity, matrix van Genuchten α and n values, and residual saturation

Feeds to: UZ Model Grid [U1010]
1-D Inversion Calibrated Properties Model [U2000]
Calibrated Properties Model [U2010]

Mountain-Scale Coupled Processes Models [U5000]
Drift-Scale Coupled Processes Models [U5040]

Responsible Organization: NEPO

Due Date for Rev00A: 5/7/99

6) **Hydrologic Properties from In situ Field Testing (U1040)**

Description: This report summarizes the estimates of hydrologic properties based on in situ field testing. This includes liquid release testing in the ESF niches, air injection testing in the ESF niches, Single Heater Test (SHT) area, and Drift Scale Test (DST) area, and gas tracer testing in the SHT and DST areas. Hydrologic properties that are used for the UZ Model and other models are either estimated or verified. These include properties such as fracture porosities and fracture van Genuchten alphas.

Input Data: Tracer testing data from tests in the SHT and DST areas.
Data from niche tests in the ESF

Feeds to: Calibrated Properties Model [U2010]
UZ PMR

Responsible Organization: NEPO

Due Date for Rev00A: 5/31/99

7) **Fracture Properties from Vertical Boreholes & Alcove Testing (U1070)**

Description: This report summarizes the fracture and fault properties determined by insitu field testing. This includes air injection testing in vertical boreholes and air injection testing and gas tracer testing in alcoves in the ESF. Properties include fracture permeability and porosity in different hydrogeologic units and near particular faults

Input Data: Gas tracer testing and air injection testing data from the Upper Tiva Canyon, Bow Ridge Fault, Upper Paintbrush Contact, and Ghost Dance Alcoves.
Data from air injection testing in vertical boreholes

Feeds to: Calibrated Properties Model [U2010]
UZ Submodels for Flow Processes [U3030]
UZ PMR

Responsible Organization: NEPO

Due Date for Rev00A: 5/31/99

8) **Alcove Moisture and Tracer Testing**

Description: This report summarizes the data collected by the USGS in alcoves in the ESF and Cross Drift. It provides an analysis of the infiltration and tracer testing performed in Alcove 1 as well as the predictive flow and tracer modeling performed.

Input Data: Moisture data from the ESF and Cross Drift
Data from the infiltration and tracer testing in Alcove 1

Feeds to: UZ Model Validation Studies [U7040]
UZ PMR

Responsible Organization: NEPO

Due Date for Rev00A: 7/30/99

9) **Ambient Geochemistry Data – LANL (U4030)**

Description: This report summarizes the available geochemistry data from the ESF Main Drift, Cross Drift, and boreholes collected by LANL. This includes ^{36}Cl, Cl and other geochemical data. It discusses the presence of bomb-pulse ^{36}Cl and tritium. It also presents prevailing and alternative conceptual interpretations.

Input Data: ^{36}Cl and Cl data from the ESF Main Drift, Cross Drift, and boreholes

Feeds to: Calibrated Properties Model [U2010]
UZ Submodels for Flow Processes [U3030]
UZ PMR

Responsible Organization: NEPO

Due Date for Rev00A: 5/31/99

10) **Ambient Geochemistry Data - USGS (U2030)**

Description: This report summarizes the available geochemistry data from the ESF Main Drift, Cross Drift, and boreholes collected by the USGS. This includes ^{36}Cl, Cl, tritium, calcite, strontium, uranium and other geochemical data. It discusses the presence of bomb-pulse ^{36}Cl and tritium. It also presents prevailing and alternative conceptual interpretations. The preliminary data from the Cl-36 Validation Study are also provided.

Input Data: ^{36}Cl, Cl, tritium, calcite, strontium and uranium data from the ESF Main Drift, Cross Drift, and boreholes

Feeds to: Calibrated Properties Model [U2010]
UZ Submodels for Flow Processes [U3030]
UZ PMR

Responsible Organization: NEPO

Due Date for Rev00A: 5/31/99

11) Transport Properties (U4070)

Description: This report will summarize the available transport properties for the lower hydrogeologic units at Yucca Mountain. This will include sorption coefficients for the radioisotopes Np, Pu, U, Tc, I, and Se.

Input Data: Sorption test data from core samples from boreholes and Busted Butte
Percent alteration of core samples from boreholes and Busted Butte

Feeds to: PA
Particle Tracking Model and Abstraction of Transport Processes [U3050]
Radionuclide Transport Models under Ambient & Thermal Conditions [U3040]

Responsible Organization: NEPO

Due Date for Rev00A: 7/30/99

12) Transport Properties from Busted Butte UZTT (U1060)

Description: The UZ transport properties in the vitric Calico Hills based on field-testing will be provided. These values will be determined through both data analysis and modeling (currently in progress). The transport parameters will include information on interactions of the fractures and matrix.

Input Data: Data from the Busted Butte UZTT

Percent alteration of core samples from Busted Butte

Feeds to: PA
Particle Tracking Model and Abstraction of Transport Processes [U3050]
Radionuclide Transport Models under Ambient & Thermal Conditions [U3040]
UZ PMR

Responsible Organization: NEPO

Due Date for Rev00A: 8/15/99

13) Enhanced Colloid Transport (U3060)

Description: This report provides documentation for the Colloid Transport Model. This enhanced process model for colloid transport includes reversible reactions, resuspension, and filtration. The process level computations are simplified through preconditioned parameters and used in an analytical expression by PA

Input Data: Colloidal transport data from Busted Butte field test

Feeds to: PA
Particle Tracking Model and Abstraction of Transport Processes [U3050]

Responsible Organization: NEPO

Due Date for Rev00A: 7/30/99

14) Development of the 3D UZ Site Scale Model Grid (U1010)

Description: The purpose is to describe the methods used to develop the numerical grids for the UZ Model using current geologic, mineralogic, and matrix hydrogeologic property data. This includes: (1) defining the location of important calibration features, (2) determining model grid layers and fault geometry based on GFM, ISM, and hydrogeologic units, (3) analyzing and extracting GFM and ISM data pertaining to layer contacts and property distributions, (4) discretizing and refining the 2-D numerical grid considering the spatial resolution of infiltration rate, (5) generating the 3D grid with added resolution at the repository horizon and within the Calico Hills, and (6) formulating the dual-permeability mesh.

Input Data: GFM 3.1 [C1035]
ISM 3.0
Fracture data for hydrogeologic units [U4040]
Hydrogeologic Units
Water Table Map
Repository Layout Configuration

Feeds to: 1-D Inversion Calibrated Properties Model [U2000]
Calibrated Properties Model [U2010]
UZ Submodels for Hydrogeologic Units [U3000]
UZ Submodels for Flow Processes [U3030]
Base Case Flow Fields for the UZ [U7000]
Mountain-Scale Coupled Processes Models [U5000]
Geostatistical Representation of CHn Formation [U7030]
UZ PMR

Responsible Organization: NEPO

Due Date for Rev00A: 5/7/99

15) 1-D Inversion Calibrated Properties Model (U2000)

Description: This report provides documentation for the 1-D Inversion Calibrated Properties Model used to provide the best estimates of base case rock properties for use by PA and other project participants. The report describes the one-dimensional inverse-modeling techniques applied to iteratively adjust input parameters to minimize the difference between the model predictions and the corresponding observations including saturations, water potentials, and pressures. The properties include matrix permeability, fracture permeability, van Genuchten parameters alpha and m for matrix, and van Genuchten parameters alpha and m for fractures for each UZ Model layer.

Input Data: Infiltration map from Infiltration Model [U1030]
UZ Model Grid [U1010]
Saturation data from boreholes
Water potential data from boreholes
Pneumatic pressure data from boreholes
Fracture properties for each model layer [U4040]
Matrix properties for each model layer [U4040]

Feeds to: PA
Calibrated Properties Model [U2010]
UZ Submodels for Hydrogeologic Units [U3000]
UZ Submodels for Flow Processes [U3030]

Responsible Organization: NEPO

Due Date for Rev00A: 5/31/99

16) Calibrated Properties Model (U2010)

Description: This report provides documentation for the Calibrated Properties Model used to provide the best estimates of base case rock properties for use by PA and other project participants. This model includes calibrations on saturation, water potential, pneumatic, temperature, and geochemical data. The report describes 1) the inverse-modeling techniques applied to iteratively adjust input parameters to minimize the difference between the 1-D model predictions and the corresponding 2- and 3-D observations including saturations, water potentials, and pressures, 2) the forward calibration techniques for calibrations on temperature and geochemical data, and 3) 3-D forward calibration techniques utilizing perched water models. The properties generated from the model include matrix permeability, fracture permeability, van Genuchten parameters alpha and m for matrix, and van Genuchten parameters alpha and m for fractures for each UZ Model layer.

Input Data: Saturation data from boreholes
Infiltration map from Infiltration Model [U1030]
UZ Model Grid [U1010]
Water potential data from boreholes
Pneumatic pressure data from boreholes
Temperature data from boreholes
Geochemical data from the ESF and boreholes [U4030, U2030]
Fracture properties for each model layer [U4040]
Matrix properties for each model layer [U4040]
Calibrated properties from 1-D inversions [U2000]
Radionuclide Transport Models under Ambient & Thermal Conditions [U3040]

Feeds to: PA
UZ Submodels for Hydrogeologic Units [U3000]
UZ Submodels for Flow Processes [U3030]
Base Case Flow Fields for the UZ [U7000]
Mountain-Scale Coupled Processes Models [U5000]

Drift-Scale Coupled Processes Models [U5040]
Seepage Models for PA [U4000]
Geostatistical Representation of CHn Formation [U7030]
UZ PMR

Responsible Organization: NEPO

Due Date for Rev00A: 6/30/99

17) **Analysis Comparing Advection-Dispersion Transport Solution and Particle Tracking (U7050)**

Description: This report presents an analysis comparing an advective-dispersive (A-D) transport solution and particle tracking. This includes simulations of radionuclide transport using a fully coupled advective dispersion flow and transport model that incorporates advection, dispersion, sorption, and decay processes. Results are compared with TSPA particle tracking results from the Viability Assessment (VA).

Input Data: 3-D flow fields used for VA
Flow and transport properties used for VA

Feeds to: TSPA
UZ PMR

Responsible Organization: PAO

Due Date for Rev00A: 5/31/99

18) **UZ Submodels for Hydrogeologic Units (U3000)**

Description: This report provides documentation for the PTn Flow and CHn Submodels. The PTn Flow numerical submodel simulates and investigates flow within the PTn hydrogeologic unit. Lateral diversion of water around this unit due to a capillary barrier effect could have important implication to repository design and performance. The model incorporates measured hydrologic property data and available geologic information. The numerical approach used to capture the transition between layers is also considered. The CHn numerical submodel simulates and investigates flow within the CHn hydrogeologic unit. Lateral diversion of water round this unit due to a permeability barrier effect could have important implications to repository design and performance. The model incorporates measured hydrologic property data and available geologic information and considers the numerical approach used to capture the transition between layers in this unit.

Input Data: Matrix property data from the ESF and boreholes
Stratigraphy data from borehole logs
Infiltration Model [U1030]
Calibrated fracture and matrix properties [U2000, U2010]
Hydrologic property data for CHn

Feeds to: Base Case Flow Fields for the UZ [U7000]
Geostatistical Representation of CHn Formation [U7030]
UZ PMR

Responsible Organization: NEPO

Due Date for Rev00A: 7/30/99

19) UZ Submodel for Flow Processes (U3030)

Description: This report includes documentation for the Perched Water, Temperature, Geochemistry, and Faults Submodels.

- The Perched Water numerical model investigates the perched water phenomena at Yucca Mountain. Field data including locations of perched water, minimum volumes of perched water bodies, and pumping test data are incorporated into the model and compared with perched water residence times derived from ^{14}C data.
- The Temperature Submodel is documented through the analysis of temperature data for calibration of the UZ Flow and Transport Model. Temperature data from boreholes are further analyzed in terms of percolation flux rates and overall heat flux.
- The geochemical submodels include the Strontium Submodel, Chloride Submodel, Chloride-36 Submodel, Sulfate Submodel, Carbon-14 Submodel, and Tritium Submodel. The Strontium Submodel incorporates the effects of rate-limited dissolution and precipitation on the concentration of a solute, in addition to dispersion, radioactive decay, and linear equilibrium adsorption. The Sr isotopic ratio in pore waters is estimated and used to constrain the flow regime and percolation fluxes. The Chloride Submodels incorporate conceptual models for the spatial and temporal variations in chloride chemistry. The Chloride-36, Carbon-14, and Tritium Submodels simulate transport along fast pathways during transient infiltration events where structural discontinuities exist in the PTn and other areas. Results from these submodels are compared with pore water concentrations at the site and in the ESF.

- The Faults submodels include those used for modeling studies to better understand the influence of faults and how to best model faults. These include a model of the Ghost Dance Fault and the Solitario Canyon Fault. The model for the Ghost Dance Fault is calibrated to moisture conditions and pneumatic pressure data. The model for the Solitario Canyon Fault is non-calibrated. For both of these, liquid flow travel times and gas flow patterns are analyzed in terms of their sensitivity to a range of fault properties.

Input Data: Geochemistry data from ESF and boreholes [U4030, U2030]
Infiltration Model [U1030]
UZ Model Grid [U1010]
Calibrated fracture and matrix properties [U2000, U2010]
Temperature data for boreholes
Pneumatic pressure data
Moisture data from the Ghost Dance Fault Alcove
Tracer and air-injection data from the Ghost Dance Fault Alcove [U1070]
Location of perched water in boreholes
Pumping test data

Feeds to: Base Case Flow Fields for the UZ [U7000]
UZ PMR

Responsible Organization: NEPO

Due Date for Rev00A: 8/27/99

20) Base Case Flow Fields for the UZ (U7000)

Description: The purpose of this activity is to provide Performance Assessment (PA) with the base-case flow fields and parameters sets to be used in TSPA-Site Suitability (TSPA-SS). It documents the simulations of percolation to the repository horizon and the water table.

Input Data: Calibrated matrix and fracture property set [U2010]
Infiltration maps from Infiltration Model [U1030]
3-D UZ Model grid [U1010]
Perched Water Submodel [U3030]
Geochemistry Submodel [U3030]
Temperature Submodel [U3030]
Faults Submodel [U3030]
PTn Submodel [U3000]
CHn Submodel [U3000]

Feeds to: PA
Abstraction of Flow Fields for RIP [U6030]
Radionuclide Transport Models [U3040]
Seepage Models for PA [U4000]
UZ PMR

Responsible Organization: NEPO

Due Date for Rev00A: 7/1/99

21) Radionuclide Transport Models under Ambient & Thermal Conditions (U3040)

Description: This report documents the modeling and analysis of radionuclide transport in the unsaturated zone under ambient and thermal conditions. The analysis includes simulations of water, gas, and solute transport within the unsaturated zone including advective transport, sorption, dispersion, diffusion, and colloidal facilitated transport. The modeling capabilities are described including the efficient simulation of the transport of radionuclides from beneath the potential repository horizon to the water table under ambient conditions and conditions of repository heat.

Input Data: Transport properties [U4070, U1060]
Calibrated fracture and matrix property set [U2010]
Base Case Flow Fields [U7000]
Source term for radionuclides [EB205]
Mountain-Scale TH Model [U5000]

Feeds to: UZ PMR

Responsible Organization: NEPO

Due Date for Rev00A: 12/10/99

22) Mountain-Scale Coupled Processes (TH, THC, THM) Models (U5000)

Description: This report provides documentation for the Mountain-Scale TH, THC and THM Model.

- The Mountain Scale Thermal-Hydrologic (TH) Model numerically simulates the potential impacts of repository decay heat on the natural hydrogeologic system including a representation of heat driven processes occurring in the far field. Predictions include liquid saturation, water vapor as gas flux, and temperature of water and rock.

- The Mountain-Scale THC model simulates mountain-scale reaction-transport processes for nonisothermal multicomponent, multiphase, and multispecies systems. It considers changes in flow and transport from the surface to the water table due to changes in permeability, porosity, and unsaturated flow parameters as a function of rock-water interaction, coupled to the full thermohydrologic calculations for dual-permeability media. Features such as the development of a low-permeability cap above the repository, modification of the PTn, and the vitric and zeolitic units below the repository are also considered.
- The report also documents the development of a comprehensive set of kinetic mineral-water reactions, including feldspars, silica phases, clay minerals, and zeolites, for a general set of aqueous and gaseous species, including CO_2 in the gas phase. It includes predictions of the chemical composition of waters (pH, salinity, etc.) that could potentially seep into drifts. The Mountain-Scale THC Model combines constraints and data from modeling of the ambient system geochemistry (3-D UZ model) and coupled processes in the thermal tests, including constraints on reaction rates from isotopic systems, such as strontium and carbon.
- The Mountain-Scale THM Model considers the potential impact of mechanical processes such as the closure and opening of fractures on unsaturated flow.

Input Data: Thermal properties for model layers [U4040]
Calibrated fracture and matrix property set [U2010]
Infiltration maps from Infiltration Model [U1030]
3-D UZ Model grid [U1010]
Geochemical thermodynamic database

Feeds to: PA
Abstraction of Coupled Processes into Flow Fields [U6010]
Radionuclide Transport Models (Thermal Conditions) [U3040]
UZ PMR

Responsible Organization: NEPO

Due Date for Rev00A: 9/15/99

23) Seepage Calibration Model & Seepage Testing Data (U4010)

Description: This report provides documentation for the Seepage Calibration Model and describes the techniques used to calibrate the model using field data from the niche liquid release tests in the ESF. It also incorporates data from other models, such as ranges in percolation rates and available information on locally altered hydraulic characteristics.

Input Data: Data from niche liquid release testing
Data from air injection testing in niches
Calibrated fracture and matrix property set [U2000, U2010]

Feeds to: PA
Abstraction of Drift Seepage & Drift-Scale Coupled Processes [U6020]
Drift-Scale Coupled Processes Models [U5040]
Seepage Models for PA [U4000]
UZ PMR

Responsible Organization: NEPO

Due Date for Rev00A: 7/15/99

24) Drift-Scale Coupled Processes (DST, THC) Models (U5040)

Description: This report documents the Drift Scale Test (DST) Thermo-Hydrologic (TH) Model, The DST Thermo-Hydrologic-Chemical (THC) Model, and the THC Seepage Model as well as provide an analyses of TH effects on seepage and provide predictions of the chemical composition of seepage into drifts.

- The DST TH model includes the effects of water and water vapor migration in the region surrounding the drift as a result of heating. Included will be boiling of water and the precipitation of water vapor. The interpretation of the heater test will develop parameters for use in predictive TH modeling.
- The DST THC Model is used to investigate and simulated the thermal effects of heating test drifts and blocks by simulating the migration of water, air and heat in response to heat imposed during single and drift scale heater tests. Interpretations from the model are used to calibrate thermal conductivity, fracture properties, and verify the numerical approach used to describe the dual continuum.
- The THC Seepage model will include the effects of mineral dissolution and precipitation in the region surrounding the drift. The analysis will consider the ambient geochemical environment as well as the interactions among the major minerals existing or expected to form as a result of alteration through heating. The analysis will consider if of silica "precipitation cap" forms above and/or below the drift and evaluate the potential changes to permeability and seepage.

- An analysis of TH effects on seepage evaluates the impact of thermal refluxing on seepage into emplacement drifts. The quantity and frequency of seeps under thermal conditions are compared to those under ambient conditions.

Input Data: Thermal properties for model layers [U4040]
Calibrated fracture and matrix property set [U2010]
Calibrated drift-scale parameters [U4010]
Geochemical thermodynamic database

Feeds to: PA
Abstraction of Drift Seepage & Drift-Scale Coupled Processes [U6020]
UZ PMR

Responsible Organization: NEPO

Due Date for Rev00A: 9/15/99

25) Seepage Models for PA including Drift Collapse & Drainage of Rocks Below the Drift (U4000)

Description: This report provides documentation for the Seepage Model for PA, the Disturbed Drift Seepage Submodel, and presents an analysis of the drainage of rock below emplacement drifts.

- The Seepage Model for PA utilizes the distribution of permeabilities derived from niche testing to stochastically simulate the 3-D flow of water in the fractured host rock in the vicinity of potential emplacement drifts under ambient conditions.
- This Disturbed Drift Seepage Submodel is developed and utilized to evaluate the impact of the partial collapse of a drift on seepage. Drift scale seepage modeling is used to evaluate the resulting changes in drift seepage.
- The analysis of drainage of rock below emplacement drifts is based on modeling studies and provides input to PA for use in transport studies and sensitivity analysis.

Input Data: Calibrated drift-scale parameters [U4010]
Boundary conditions from UZ Flow and Transport Model [U7000]
EBS/NFE Drift Collapse Model [EB231]
Calibrated fracture and matrix property set [U2010]

Feeds to: PA

Abstraction of Drift Seepage & Drift-Scale Coupled Processes
[U6020]
UZ PMR

Responsible Organization: NEPO

Due Date for Rev00A: 8/31/99

26) Analysis of Infiltration Uncertainty (U4060)

Description: This analysis considers the uncertainties in the Infiltration Model. Infiltration distributions and confidence limits are produced using statistical techniques. Monte Carlo analyses provides distribution rates for use in the UZ Model and for evaluation in PA sensitivity studies. This analysis provides further justification of the use of the Infiltration Model.

Input Data: Infiltration Model [U1030]

Feeds to: TSPA
Sensitivity Studies [U7070]
UZ PMR

Responsible Organization: NEPO

Due Date for Rev00A: 9/30/99

27) Abstraction of Flow Fields for RIP (U6030)

Description: This report provides details as to the conversion of flow fields from TOUGH2 for use with the FEHM particle tracking algorithm. This provides documentation of the conversion process.

Input Data: Flow fields from UZ Flow and Transport Model [U7000]

Feeds to: TSPA
Analysis of Base-Case Particle Tracking Results of the Base-Case Flow Fields [U7060]
Sensitivity Studies [U7070]
UZ PMR

Responsible Organization: PAO

Due Date for Rev00A: 9/30/99

28) Abstraction of Coupled Processes (TH, THC, & THM) into Flow Fields (U6010)

Description: This analysis evaluates the impact of TH, THC, and THM processes on large-scale fluid flow. It documents the abstraction method for the Mountain-Scale TH and THC Models. This will include the evaluation of the impacts of site-scale processes including spatial variations in the chemistry of infiltrating waters, temporal variations due to potential future climate change, and changes to properties such as porosity, permeability, sorption, etc.

Input Data: Durable change in rock properties from THC modeling [U5000]
Mountain-Scale THC Model [U5000]
Mountain-Scale TH Model [U5000]
Mountain-Scale THM Model [U5000]

Feeds to: TSPA
Sensitivity Studies [U7070]
UZ PMR

Responsible Organization: PAO

Due Date for Rev00A: 9/30/99

29) Abstraction of Drift Seepage & Drift-Scale Coupled Processes (TH, THC, and THM) (U6020)

Description: This report documents the abstraction method for the Seepage Model for PA and drift-scale TH, THC and THM models for incorporation into TSPA-SR/LA. It documents the probability distributions generated for drift seepage. It provides an evaluation of the impact of the processes of thermal refluxing on the emplacement drift seepage. In addition to the quantity and frequency of seeps during the thermal period, the chemical content of water seeping into drifts is considered. It also documents the development of a model with thermal hydrology so as to include the impacts of waste package variability (e.g., differing heat outputs), radiant heat transfer processes, design features, etc., on thermal seepage. The model provides data for the abstracted TSPA seepage model during the thermal perturbation but also be used to ensure that seepage processes and its impacts on temperature and relative humidity in the drift are properly taken into account.

Input Data: Calibrated drift-scale parameters [U4010]
Seepage Model for PA [U4000]
THC Seepage Model [U5040]
TH Effects on Seepage [U5040]

Feeds to: TSPA
Sensitivity Studies [U7070]
UZ PMR

Responsible Organization: PAO

Due Date for Rev00A: 10/22/99

30) **Particle Tracking Model and Abstraction of Transport Processes (including colloids, decay, diffusion, etc.) (U3050)**

Description: This reports provides documentation for the particle tracking model, its conceptual models, and the abstraction methods for transport processes for TSPA-SR. This will include a description of the various model components in the FEHM particle tracking algorithm (e.g., matrix diffusion and sorption), the abstraction of the colloidal transport model, and the radionuclide decay model in particle tracking algorithm. The abstraction will include the effects of advection, sorption, dispersion, diffusion and colloidal facilitated migration. This includes a description and justification of the abstraction methodology.

Input Data: FEHM particle tracking algorithm
Matrix diffusion and sorption properties [U4070]
Radionuclide decay submodel
Transport properties [U4070, U1060]
Model colloid parameters [U3060]
Colloid Transport Model [U3060]

Feeds to: TSPA
Analysis of Base-Case Particle Tracking Results of the Base-Case Flow Fields [U7060]
Sensitivity Studies [U7070]
UZ PMR

Responsible Organization: PAO

Due Date for Rev00A: 9/30/99

31) **UZ Model Validation Activities (U7040)**

Description: This report provides documentation for the validation studies completed for the UZ Flow and Transport Model. These include blind predictions for water potential, temperature, gas pressure, and moisture conditions in the East-West Cross Drift, ESF niches, the Drift-to-Drift Alcove, and vertical boreholes. Also included are blind predictions for perched water in vertical boreholes, seepage flow in niches, and tracer testing in Alcove 1.

Input Data: Water potential data from the Cross Drift, ESF niches, the Drift-to-Drift Alcove, and vertical boreholes
Natural Analogue Studies

Feeds to: UZ PMR

Responsible Organization: NEPO

Due Date for Rev00A: 12/10/99

32) **Natural Analogues U7020**

Description: This report provides a summary of the analysis of data from natural analogues for the Yucca Mountain site. This analysis includes a literature review summarizing the state of knowledge from past analogue studies in the international nuclear waste community and elsewhere. It provides recommendations for application of analogue information to performance assessment and design. Data from selected natural and anthropogenic analogues are analyzed to determine their potential use for the project. Simplified modeling simulations for selected analogues are presented to build confidence in radionuclide transport models and other process models over long time periods and large spatial scales.

Input Data: Data from selected analogue sites

Feeds to: UZ Model Validation Activities (U7040)
UZ PMR

Responsible Organization: NEPO

Due Date for Rev00A: 8/27/99

33) **Geostatistical Representation of CHn Formation (U7030)**

Description: This report describes the methods and analysis performed to provide and evaluate a geostatistical representation for selected hydrologic parameters in the Calico Hills hydrogeologic unit. The parameters were selected based on the availability of adequate data and the potential impact on performance. The product is a 2-D sensitivity analysis to determine impact of heterogeneities in the Calico Hills matrix unit on groundwater flow and transport. The results are compared with the two limiting conceptual models of perched water (flow-through and permeability barrier).

Input Data: Geostatistical representation of matrix permeability from the Rock Properties Model [C1040]
2-D UZ Model cross-section grid [U1010]
CHn Submodel [U3000]
Calibrated matrix and fracture property set [U2010]

Feeds to: Sensitivity Studies [U7070]
UZ PMR

Responsible Organization: NEPO

Due Date for Rev00A: 9/30/99

34) **Analysis of Base-Case Particle Tracking Results of the Base-Case Flow Fields (U7060)**

Description: This report provides an analysis of the base-case particle tracking results utilizing the base-case flow fields. Flux and cumulative breakthrough curves at the water table are provided and evaluated to provide insight into subsystem performance for the unsaturated zone.

Input Data: Converted flow fields from UZ Model [U6030]
Particle Tracking Model [U3050]

Feeds to: UZ PMR

Responsible Organization: PAO

Due Date for Rev00A: 11/5/99

35) **Sensitivity Studies for Site-Scale UZ flow, Seepage into Drifts, and Site-Scale UZ transport (U7070)**

Description: This report documents the sensitivity studies associated with site-scale UZ flow, seepage into drifts, and site-scale UZ transport. For site-scale UZ Flow, this includes effects of altered property sets from THMC analyses, effects of different climate and infiltration ranges, effects of longer than 10,000 year time frame, and use of discrete weeps model in conjunction with site-scale model to calculate weep spacing and seepage. For site-scale UZ transport, this includes effects of variations of parameter ranges (sorption, solubilities, diffusion, etc.), effects of different conceptual models, effects of dispersion, and matrix diffusion, colloid transport, effects of different climate and infiltration ranges, and the effects of longer than 10,000 year time frame. For seepage into drifts, this includes effects of altered property sets from THMC analyses, effects of different climate and infiltration ranges, and effects of longer than 10,000 year time frame.

Input Data: Distributions for surface infiltration rates [U4060]
Converted flow fields from UZ F&T Model [U6030]
Abstraction of coupled processes into flow fields [U6010]
Abstraction of seepage modeling [U6020]
Abstraction of coupled process into seepage models [U6020]
Abstraction of transport processes [U3050]
Abstraction of colloid transport [U3050]
Source term for radionuclides [EB205]
TSPA RIP

Feeds to: UZ PMR

Responsible Organization: PAO

Due Date for Rev00A: 12/10/99

AP-3.10Q REPORTS FROM OTHER PMRs

These other PMR's should be referred to for more details on these AP-3.10Q Reports

GFM 3.1 (C1035) – ISM PMR

Description: This report documents the Geologic Framework Model (GFM). GFM 3.1 represents the lithostratigraphic and structural data for Yucca Mountain. It contains numerous data files describing the 3-D location and orientation of faults, land-surface topography, geologic structure at unit contacts, and lithostratigraphic layer thickness. This information includes the revisions in stratigraphy based on SD-6 and WT-24.

Input Data: Lithostratigraphies from boreholes [C1000]
Surface geological maps of YM
Geologic contacts from the ESF
Measured sections

Feeds to: UZ Model Grid [U1010]

Responsible Organization: WCFS (R. Clayton)

ISM 3.1 Rock Properties Model (C1040) – ISM PMR

Description: The distributions of matrix properties, including porosity and matrix permeability as well as other properties, are incorporated into a three-dimensional stratigraphic model. These property sets are based on field data, and geostatistical techniques are used to provide estimates of property values where no data are present. These distributions will be updated based on the recent analysis and samples from SD-6 and WT-24.

Input Data: Matrix property data from core samples
GFM 3.1 [C1035]

Feeds to: Geostatistical Representation of CHn Formation [U7030]

Responsible Organization: SNL (C. Rautmann)
WCFS (R. Clayton)
USGS (L. Flint)

ISM 3.1 Min/Pet Model (C1045) – ISM PMR

Description: Represents the spatial distribution of mineral abundances. It is constructed from numerous borehole samples. This model is used as the basis for mineralogic information and resolve spatial variations in percent zeolite distribution. For the UZ Model this information is used for the units Tptpv1, Tpbt1, Tac, and Tacbt. The model is based on the stratigraphy of GFM 3.1.

Input Data: GFM 3.1 [C1035]
Mineralogic data from boreholes

Feeds to: UZ PMR

Responsible Organization: WCFS (R. Clayton), LANL (B. Carey)

EBS Drift Collapse Model (EB231) – EBS PMR

Description: For the UZ Flow and Transport PMR, this report provides the shape of the drift as a function of time for use in the analysis of drift seepage under conditions of partial drift collapse. This report contains additional documentation and analyses for use in the EBS PMR.

Feeds to: Seepage Models for PA [U4000]

<u>**EBS Radionuclide Transport Model (EB205) – EBS PMR**</u>

Description: For the UZ Flow and Transport PMR, this report provides a source term of radionuclide concentrations for use in the mountain-scale radionuclide transport models. This report contains additional documentation and analyses for use in the EBS PMR

Feeds to: Radionuclide Transport Models under Ambient & Thermal Conditions [U3040]
Sensitivity Studies [U7070]

			ANALYSIS AND MODEL REPORTS SUPPORTING THE SZ FLOW AND TRANSPORT MODEL PMR	
			Title	Resp. Org.
		1	Hydrologic Framework Model	NEPO
		2	Water Level Data	NEPO
		3	SZ Site-Scale Model Flow Boundary Conditions	NEPO
		4	Geochemistry	NEPO
		5	Colloid-Facilitated Pu Transport Model	PAO
		6	Natural Analogs	NEPO
		7	Geostatistical Methodology	NEPO
		8	Model Validation	NEPO
		9	Process Model Uncertainty	NEPO
		10	Summary and Synthesis Transport Data Input	NEPO
		11	SZ Site-Scale Model Transport Methodology and Transport Component	NEPO
		12	Flow Model Calibration	NEPO
		13	Uncertainty Distributions for Stochastic Parameters	PAO
		14	Probability Distribution for Flowing Interval Spacing	PAO
		15	Input and Results of Base Case SZ Flow and Transport Model Runs for TSPA	PAO
		16	Features, Events, and Processes	PAO
		17	Summary and Synthesis Transport Data Input	NEPO

Data and Analysis Reports Supporting the Saturated Zone Flow and Transport Process Model Report

1) Hydrogeologic Framework Model (B1010) SPP2025

Description: This model will document the revised hydrogeologic framework used in the SZ site-scale flow and transport model. The revisions include:

- Deepening the lower boundary to make it consistent with that of the regional flow model and coincident with the natural no flow.
- Incorporating available data from Nye County wells and boreholes SD-6 and WT-24, as available.
- Incorporating the new geological maps and cross sections.

Input Data: Lithologic logs, geological maps and cross sections, ISM model, and the new Nye County lithologic logs.

Feeds to: Final Calibrated Flow Model; Uncertainty Distribution for Stochastic Parameters

Responsible Organization: NEPO

Data Feed Due Date: 5/15/99

2) Water Level Data (B1030) SPP1000

Description: This package will document the water level data. Based on defined criteria, water levels will be flagged as to whether they are likely to represent perched conditions. The water level data will be used as a target calibration for the flow model.

Input Data: Water level data including the new Nye County data.

Feeds to: Final Calibrated Flow Model

Responsible Organization: NEPO

Data Feed Due Date: 5/15/99

3) SZ Site-Scale Model Flow Boundary Conditions (B1040) SPP1040

Description: This analysis will document the lateral and recharge boundary conditions for groundwater used in the SZ site-scale flow and transport model. The values of volumetric groundwater flow rates along the lateral boundaries of the SZ model domain will be taken from the results of the SZ regional-scale flow model and adapted for use as specified-flux boundary conditions for the SZ site-scale model. Values of recharge to the SZ site-scale model for use as specified-flux boundary conditions will be determined using three components. In the region corresponding to the UZ site-scale flow model domain, the recharge will be determined using the groundwater flux at the bottom boundary (i.e., the water table) as simulated by the UZ site-scale flow model. In areas beyond the extent of the UZ site-scale flow model, the values of distributed recharge using the modified Maxey-Eakin method of the SZ regional-scale flow model will be used to specify the upper boundary conditions of the SZ site-scale model. Specified-flux recharge conditions along the channel of Fortymile Wash will be taken from estimates of stream channel loss published by USGS .

Input Data: Results from the UZ model; results from the 1997 regional model; and results from the Fortymile wash infiltration study.

Feeds to: Final Calibrated Flow Model

Responsible Organization: NEPO

Data Feed Due Date: 5/15/99

4) Geochemistry (B2010) SPP2025

Description: This analysis will document the analysis of geochemical and isotopic data to constrain rates and directions of ground-water flow near Yucca Mountain and the timing and magnitude of recharge in the Yucca Mountain vicinity. The geochemical and isotopic data will be examined with regard to the possible dilution of groundwater recharge from Yucca Mountain by mixing with groundwater downgradient from the potential repository site.

Input Data: All geochemical data and studies.

Feed to: Final Calibrated Flow Model

Responsible Organization: NEPO

Data Feed Due Date: 5/15/99

5) Colloid-Facilitated Pu Transport Model (B2005) SPP1075

Description: This analysis will consist of the methods, assumptions, and results of 1-D reactive transport modeling of colloid-facilitated Pu transport in the SZ.

Input Data: Data feeds include laboratory data on the sorption characteristics of the tuff matrix and the kinetic sorption/desorption rates onto colloids. Field data on concentrations of natural colloids in groundwater and on colloid filtration from the C-wells tracer tests will also be used. Input from the 3-D SZ site-scale flow and transport model will be used to define the flowpaths. Field observations from apparent colloid-facilitated Pu migration at Pahute Mesa will also be considered in this model.

Feeds to: Uncertainty Distribution for Stochastic Parameters

Responsible Organization: PAO

Data Feed Due Date: 7/1/99

6) Natural Analogues (B2065) SPP2080

Description: This report provides a summary of the analysis of data from natural analogue sites relevant to SZ flow and transport processes. The analysis includes a Recommendations are made for application of SZ process analogues to PA and possibly to design.

Input Data: Information from published literature describing studies (from the international community and the U.S.), including retardation in saturated alluvium, dispersion and dilution in contaminant plumes, colloid transport, and other radionuclide transport in the SZ. Results of modeling simulations are presented for use of Hanford data on transport of tritium in saturated alluvium as a test of modeling dispersion in the SZ flow and transport model.

Feeds to: PA and possibly to design.

Responsible Organization: NEPO

Data Feed Due Date: 8/2/99

7) Geostatistical Methodology (B1060) SPP3000

Description: This analysis will document the sensitivity analysis of the effects of heterogeneity at the sub grid block scale on the calculated dispersivities and the variability in advective velocity. A select number of cells within the flow model would be chosen and a fine scale discretization within these select cells would be populated with heterogeneous permeabilites through geostatistical simulation. These detailed permeability models would then be used as input to the new transport model being implemented in FEHM. The results of the transport work will be a sensitivity analysis of how sub-grid block heterogeneity affects the overall transport, specifically with respect to dispersion and variation in advective velocity. Several conceptual models of fracture permeability would be implemented through the geostatistical simulations.

Input Data: Data feeds will include fault mapping at the Yucca Mountain site, the distribution of flowing intervals in the SZ derived from well flowmeter surveys, information on the C-wells, and statistical information on "background" fracture network permeability from air permeability and single borehole SZ tests.

Feeds to: Uncertainty Distribution for Stochastic Parameters

Responsible Organization: NEPO

Data Feed Due Date: 7/1/99

8) Model Validation (B2075) SPP4010

Description: This analysis will document model validation activities. This analysis will demonstrate the validity of the model and discusses the suitability of the model for its intended application. It will include demonstration of the validity of the data used to support the model validation, as well as demonstration of the validity of the codes that support the model. Results of expert elicitation panel used to support model validation will be included. The analysis will also include the use of natural analogues at Hanford, Idaho (INELL), and other analogues in the model validation.

Input Data: Data feeds for this analysis package include the numerical model and natural analogues analysis.

Feeds to: PA

Responsible Organization: NEPO

Data Feed Due Date: 8/2/99

9) Process Model Uncertainty (B2070) SPP4010

Description: This analysis will document sensitivity analysis to bound uncertainty in the SZ flow and transport model. The analysis will discuss the uncertainties in the model and the assumptions and bases thereof associated with the uncertainties.

Input Data: Data feeds for this analysis package include the numerical model and natural analogues analysis.

Feeds to: PA

Responsible Organization: NEPO

Data Feed Due Date: 8/2/99

10) Summary and Synthesis Transport Data Input (B1068) SPP2000

Description: This package will document the site scale model transport input data used in the model. The data include sorption data, dispersion data, etc. The analysis will document extracting input parameters for transport from the C-Wells testing, other field measurement, and laboratory testing.

Input Data: Data feeds for this analysis package include all laboratory data on radionuclide sorption, matrix diffusion, and colloid-facilitated transport. Feeds will also include data from conservative and reactive tracer tests at the C-wells.

Feeds to: PA and SZ Site-Scale Model Transport Methodology and Transportation Component

Responsible Organization: NEPO

Data Feed Due Date: 8/1/99

11) SZ Site-Scale Model Transport Methodology and Transport Component (B1080) SPP3025

Description: This package will document the streamline particle tracking methodology used in the SZ site-scale model. The package will also include input and output decks for FEHM of the SZ site-scale flow and transport model. The expected values of transport parameters will be included in the input files.

Input Data: Data feeds will include the calibrated flow model component, statistical analyses of matrix porosity and bulk density from the "Uncertainty Distributions of Stochastic Parameters" AP-3.10Q analysis described below, and the summary and synthesis transport data input. In addition, the matrix porosity and bulk density properties from the ISM model will be input for the area and geologic units covered by this model.

Feeds to: PA

Responsible Organization: NEPO

Data Feed Due Date: 8/2/99

12) Flow Model Calibration (B2030) SPP3070

Description: This analysis will document the calibration of the site-scale saturated zone flow model. The calibration will proceed from simple to more complex conceptual models and will include recharge estimates and lateral boundary conditions as described in the AP-3.10Q document "SZ Site-Scale Model Flow Boundary Conditions". The conceptual features will include faults, fractures, and permeability zones that have been identified for inclusion in the regional scale model as well as detailed features that will be fully documented. The final calibrated model will include a description of particle paths from the proposed repository region as well as a discussion of the sensitivity of model parameters.

Input Data: Data feeds to this analysis package include: The hydrogeologic framework model, the water level data, the SZ site-scale model flow boundary conditions package data, and the geochemistry package data.

Feeds to: PA

Responsible Organization: NEPO

Data Feed Due Date: 8/2/99

13) Uncertainty Distributions for Stochastic Parameters (B2035) SPP3090

Description: The uncertainty distributions for all stochastic parameters to be used in TSPA analyses of SZ flow and transport will be documented and justified in this analysis.

Input Data: Data feeds for this activity will include the "Summary and Synthesis of Transport Data Report" AP-3.10Q analysis described above. Data will also be taken from published reports on matrix properties in boreholes. Data from the "Uncertainty Distribution for Flowing Interval Spacing" AP-3.10Q analysis will also included.

Feeds to: Input Base Case

Responsible Organization: PAO

Data Feed Due Date: 10/1/99

14) Probability Distribution for Flowing Interval Spacing (B1095) SPP3050

Description: This analysis will document details of the development of the uncertainty distribution for the spacing of flowing intervals (e.g., fractures, fracture zones) in the SZ.

Input Data: Data feeds will include published reports of wellbore flowmeter surveys, fracture orientation logs and temperature logs from boreholes in the SZ.

Feeds to: Uncertainty Distribution for Stochastic Parameters

Responsible organization: PAO

Data Feed Due Date: 6/1/99

15) Input and Results of Base Case SZ Flow and Transport Model Runs for TSPA (B2040) SPP4050

Description: This package will document the stochastic SZ site-scale flow and transport model runs for TSPA. Input and output decks from FEHM will be archived for all realizations of the SZ flow and transport system. Unit breakthrough curves at the accessible environment for use in the convolution integral method of the TSPA calculations will be documented in this package.

Input Data: The inputs to the base case SZ model runs will be the SZ site-scale flow and transport model and the uncertainty distributions for stochastic parameters, described above.

Feeds to: SZ PMR

Responsible Organization: PAO

Data Feed Due Date: 11/15/99

16) Features, Events, and Processes (B2078) SPP4070

Description: This analysis will systematically tabulate the features, events, and processes (FEPs) relevant to SZ flow and transport. Disposition (i.e., included or excluded) of all FEPs will be documented and justified in this package.

Input Data: The primary input to this activity will be the FEPs database developed for TSPA.

Feeds to: SZ PMR

Responsible Organization: PAO

Data Feed Due Date: 9/30/99

17) Summary and Synthesis Transport Data Input (B1068)

Description: Not available at this time.

Input Data:

Feeds To:

Responsible Organization: NEPO
Due Date: 16 Jun 99

18) Final Calibrated Flow Model (B2020)

Description: Not Available at this time.

Input Data:

Feeds To:

Responsible Organization: NEPO

Due Date: 17 May 99

ANALYSIS AND MODEL REPORTS SUPPORTING THE NEAR FIELD ENVIRONMENT PMR		
	Title	Resp. Org.
1	ESF and LBT (results taken from thermal tests and how they are applied in process-level models)	NEPO
2	THC Processes In The Near-Field Host Rock and drift thermodynamic environment	NEPO
3	Analysis of THC Processes/impacts on emplacement drift water chemistry/gas comp	NEPO
4	Description of base case results of NFE thermodynamic environment including THC and THM (if time permits)	NEPO
5	Base case results of NFE for in-drift water chemistry/gas comp	NEPO
6	Sensitivity Analyses, Results and Abstractions	NEPO
7	Conceptual Flow Models For Heat And Fluid Flow	PAO
8	Repository Design Configuration And Heat Output	PAO
9	THM Processes In The Near And Far-Field Rock	PAO
10	THM Processes In The Near- And Far-Field Host Rock	PAO
11	TH Multiscale Model And Abstraction Method—Assumption Testing And Analysis	PAO
12	Abstractions of Base-Case Runs For NFE thermodynamic environment	PAO
13	Abstractions of NFE in-drift water chemistry/gas composition	PAO
14	Abstraction of THM processes in the Near-Field	PAO
15	Abstraction of Thermal Effects On Drift Seepage	PAO
16	Features, Events, and Processes (FEPs)	PAO
17	Natural Analogs	NEPO
18	Model Validations	NEPO
19	ESF and LBT Thermal Test Results	NEPO
20	ESF and LBT Thermal Test Results TM	NEPO

Data and Analysis Reports Supporting the Near-Field Environment Process Model Report

1. **ESF and LBT (results taken from thermal tests and how they are applied in process-level models) – N1040, N1090, N2000 (SLP7082, SLP7194, SLP7202)**

   Description: Implementation of thermal tests results in conceptual flow and numerical models.

   Input Data: None

   Feeds to: THM processes in the near and far-field rock – N2010
   Conceptual flow models for heat and fluid flow – N1050
   THC Processes In the Near-Field Host Rock – N2050

   Responsible Organization: NEPO

   Due Date: TBD (insufficient data to complete)

2. **THC Processes In The Near-Field Host Rock and drift thermodynamic environment– N3000 (SPP7090)**

   Description: Analysis of important THC processes and their impacts on the emplacement drift thermodynamic environment (temperature, relative humidity, air mass fraction) as obtained from the TH multiscale modeling and abstraction method.

   Input Data: THC Processes in the Near-Field Host Rock – N2050

   THM processes in the near- and far-field host rock – N2080

   Feeds to: THC processes in the Near-Field – N3030

   Responsible Organization: NEPO

   Due Date: 30Aug99

3. **Analysis of THC Processes/implacts on emplacement drift water chemistry/gas comp - N3010 (SPP7106)**

   Description: Analysis of THC processes and their impacts on the emplacement drift water chemistry and gas-phase composition entering the top of the emplacement drift.

Input Data: Radionuclide release EB 310 (from EBS PMR)
EBS Radionuclide Transport Chemistry (from EBS PMR)
Water Composition EB 300 (from EBS PMR)
UZ F&T Coupled Processes (from UZ PMR-U2030)

Feeds to: THC processes in the Near-Field – N3040

Responsible Organization: NEPO

Due Date: 30Aug99

4. **Description of base case results of NFE thermodynamic environment including THC and THM – N3030 (SL2000M4)**

Description: Description of the base case NFE reactive transport models for drift thermodynamic environment as implemented in the multiscale modeling and abstraction method. This AP-3.10Q results in base case temperature, relative humidity, thermally driven emplacement seepage, and air mass fraction inside/into the emplacement drift for the base case hydrologic property set(s) and reference repository design. It includes the effects of THC and THM (if time permits).

Input Data: Define base-case runs for NFE – NTBD
THC processes in the near-field host rock – N3000

Feeds to: Define base-case runs for NFE – N3060
Thermal effects on drift seepage - N3070
Preliminary results to EBS and WP Degradation PMRs

Responsible Organization: NEPO

Due Date: 02Oct99

5. **Base case results of NFE for in-drift water chemistry/gas comp– N3040 (SL20002M4)**

Description: Description of the base case NFE reactive transport models for in drift water chemistry and gas-phase composition entering the emplacement drift obtained from a drift-scale model.

Input Data: THC processes in the near-field host rock - N3010
Plugging and Drainage in Rock – TBD from EBS PMR

Feeds to: THC processes in the Near-Field – N3080
Preliminary results to EBS and WP Degradation PMRs

Responsible Organization: NEPO

Due Date: 02Oct99

6. **Sensitivity Analyses, Results and Abstractions – NTBD (TBD)**

Description: If time allows, analyses describing the TH/THM/THC sensitivity studies associated with NFE documented for the Level 4 PMR.

Input Data: Define base-case runs for NFE – N3060
Thermal effects on drift seepage - N3070
THC processes in the Near-Field – N3080
THM processes in the Near-Field – N3050

Feeds to: PMR future Revs

Responsible Organization: NEPO

Due Date: TBD

7. **Conceptual Flow Models For Heat And Fluid Flow – N1050 (SLP7122)**

Description: Analysis describing the applied conceptual model for fracture/matrix flow and heat transfer as used in UZ Flow and Transport and how it is applied to NFE.

Input Data: ESF and LBT (results taken from thermal tests and how they are applied in process-level models) – N1040
UZ F&T Climate and Infiltration (from UZ PMR-U1020, U1030)
UZ F&T Hydrologic Property Sets (from UZ PMR-U2000, U2010)
UZ F&T Conceptual Flow Model (from UZ PMR-U1080)

Feeds to: THM processes in the near and far-field rock – N2010

Responsible Organization: PAO

Due Date: 30Jul99

8. **Repository Design Configuration And Heat Output – N1060 (SLP7130)**

Description: Analysis describing the design configuration (AML, layout, footprint, elevation, and preclosure ventilation) and associated heat output (aging, blending, required decay curves, repository total).

Input Data: QAP 3-12 Transmittals

Feeds to:

Responsible Organization: PAO

Due Date: 30Jul99

9. THM Processes In The Near And Far-Field Rock – N2010 (SLP7210)

Description: Analysis describing the thermally driven model and constitutive relationships used for flow property alterations.

Input Data: Conceptual flow models for heat and fluid flow – N1050
ESF and LBT (results taken from thermal tests and how they are applied in process-level models) – N2000

Feeds to: Analysis of THM physical processes in the near- and far-field host rock – N2080

Responsible Organization: PAO

Due Date: 15Aug99

10. THM Processes In The Near- And Far-Field Host Rock – N2080 (SPP7058)

Description: Analyses describing the abstraction of thermal-mechanical effects on flow fields and near drift processes such as drift seepage flow properties.

Input Data: THM processes in the near and far-field rock – N2010

Feeds to: THC processes in the near-field host rock – N3000
THM processes in the Near-Field – N3050

Responsible Organization: PAO

Due Date: 30Sept99

11. TH Multiscale Model And Abstraction Method—Assumption Testing And Analysis – N3020 (SPP7114)

Description: Analysis describing the usage of alternative heat transfer conceptual models in the submodels used in the TH multiscale modeling and abstraction method. Also describes the usage of the methodology as a reasonable representation of interaction with TH processes.

Input Data: None

Feeds to:

Responsible Organization: PAO

Due Date: 30Aug99

12. Abstractions of Base-Case Runs For NFE thermodynamic environment– N3060 (SL20006M4)

Description: Analysis describing the abstraction(s)/results of the base case NFE including required binning procedures for drift thermodynamic environment. This includes binned temperature, relative humidity, and air mass fraction inside the emplacement drift for different repository subregions.

Input Data: THC processes in the Near-Field – N3030

Feeds to: Preliminary results to EBS and WP Degradation PMRs
Direct to TSPA-SR calculations (in RIP)

Responsible Organization: PAO

Due Date: 30Oct99

13. Abstractions of NFE in-drift water chemistry/gas composition– N3080 (SL20012M4)

Description: Analysis describing the abstraction(s) of the NFE base case in-drift water chemistry and gas-phase compositions for required TSPA models and established cases.

Input Data: Base case results of NFE for in-drift water chemistry/gas comp– N3040

Feeds to: Preliminary results to EBS and WP Degradation PMRs

Responsible Organization: PAO

Due Date: 30Jul99-30Oct99

14. Abstraction of THM processes in the Near-Field – N3050 (SL20004M4)

Description: Analysis describing the abstraction of the base case NFE including THM processes.

Input Data: THM processes in the near- and far-field host rock – N2080

Feeds to: Preliminary results to EBS and WP Degradation PMRs

Responsible Organization: PAO

Due Date: 30Oct99

15. Abstraction of Thermal Effects On Drift Seepage - N3070 (SL20010M4)

Description: Analysis describing the abstraction of thermally driven seepage results of base case NFE into TSPA.

Input Data: THC processes in the Near-Field – N3030

Feeds to: Preliminary results to EBS and WP Degradation PMRs
Direct to TSPA-SR calculations (in RIP)

Responsible Organization: PAO

Due Date: 30Nov99

16. Features, Events, and Processes (FEPs) – N3085 (TBD)

Description: Discussion of FEPs included in AP-3.10Q analyses (described in above analyses) or excluded in AP-3.10Q analyses and to be described in this AP-3.10Q.

Input Data: TBD

Feeds to: Most AP-3.10Qs

Responsible Organization: PAO

Due Date: TBD

17. **Natural Analogs (N3086)**

Description: Not available at this time.

Input Data:

Feeds to:

Responsible Organization: PAO

Due Date: 29 Sep 99

18. **Model Validations (N3087)**

Description: Not available at this time.

Input Data:

Feeds to:

Responsible Organization: PAO

Due Date: 27 Oct 99

19. **ESF and LBT Thermal Test Results (N1090)**

Description: Not available at this time.

Input Data:

Feeds to:

Responsible Organization: NEPO

Due Date: 9 Sep 99

20. **ESF and LBT Thermal Test Results TM (N2000)**

Description: Not available at this time.

Input Data:

Feeds to:

Responsible Organization: NEPO

Due Date: 9 Sep 99

ANALYSIS AND MODEL REPORTS SUPPORTING THE WASTE PACKAGE PMR		
	Title	Resp. Org.
1	Environment on the surface of drip shield and waste package barriers	WPO
2	Juvenile Failures	WPO
3	Phase Stability and Aging	WPO
4	Mechanical Failures due to Rockfall (including seismic induced)	WPO
5	General Corrosion of Waste Package Barrier	WPO
6	General Corrosion of the Drip Shield	WPO
7	Localized Corrosion Model for Waste Package Barrier Materials	WPO
8	Localized Corrosion Model for the Drip Shield	WPO
9	Stress Corrosion Cracking Model for Waste Package Barriers	WPO
10	Stress Corrosion Cracking Model for Drip Shield	WPO
11	Hydrogen Induced Cracking in Titanium	WPO
12	Degradation of Stainless Steel Structural Material	WPO
13	Waste Package Surface Chemistry	PAO
14	Abstraction of Mechanical Failures due to Rockfall (including seismic-induced rockfall)	PAO
15	Abstraction of General Corrosion of Waste Package Barrier	PAO
16	Abstraction of General Corrosion of the Drip Shield	PAO
17	Abstraction of Localized Corrosion Model for Waste Package Barrier Materials	PAO
18	Abstraction of Localized Corrosion Model for the Drip Shield	PAO
19	Abstraction of Stress Corrosion Cracking Model for WP Barriers	PAO
20	Abstraction of Stress Corrosion Cracking Model for Drip Shield	PAO
21	Abstraction of Hydrogen Induced Cracking in Titanium Drip Shield	PAO
22	Abstraction of Degradation Processes of Stainless Steel Structural Material	PAO
23	Abstraction of Water Chemistry Evolution Inside Breached Waste Package	PAO
24	Abstraction of WAPDEG Analysis Results for Input to TSPA Analysis	PAO
25	FEP Screening	PAO
26	Environment on Drip Shield Surfaces	WPO
27	NFE In-Drift T, H Analyses	WPO

Analysis and Model Reports Supporting the Waste Package Process Model Report (PMR)

1) Environment on the surface of drip shield and waste package barriers (W1045, W2055)

Description: This model will address the evolution and stability of salt deposits on the drip shield and waste package in the presence of drips and the chemistry of water film as a function of temperature and relative humidity.

Input data: In-drift Seepage and dripping conditions (T, RH for dripping). In-drift bulk geochemical conditions. Handbook data on solubility of various salts.

Feeds to: Drip shield/waste package local corrosion. Stress corrosion cracking of waste package barrier.

Responsible Organization: WPO

Due Date: 23 Aug 99 for W1045; 30 Sep 99 for W2055

2) Juvenile Failures (W2070)

Description: This process model will address the probability of waste package materials defects, waste package fabrication process including closure weld, the probability of waste package fabrication defect and their uncertainty and variability, and the consequences of the defect on waste package failure (e.g., number of potential failure sites and flaw size distribution) and their uncertainty and variability.

Input data: Manufacturing information data.

Feeds to: Localized corrosion model for the waste package barrier. Stress corrosion cracking model for waste package barrier.

Responsible Organization: WPO

Due Date: 2 Sep 99

3) Phase Stability and Aging (W1060)

Description: This process model will address degradation of the waste package barriers resulting from long-term exposure to elevated temperatures, degradation rate as a function of exposure conditions and formation of grain boundary precipitates and potential number and locations of failure sites and uncertainty and variability of the above degradation process.

Input data: Data on samples aged at Haynes International Inc. at various temperatures and for different times. These samples have been examined at LLNL to provide data to support the modeling effort. Published literature data.

Feeds to: Localized corrosion model for waste package barrier materials.
Mechanical failure model for waste package barrier materials.

Responsible Organization: WPO

Due Date: 23 Aug 99

4) Mechanical Failures due to Rockfall (including seismic induced) (W1080)

Description: This process model will address waste package failures due to rockfall through an analysis of critical rock size to fail (cause through-cracks in) waste package as a function of remaining waste package structural components (e.g., barrier thickness), failure mode characteristics (e.g., number potential failure sites), and uncertainty and variability of the rock-fall failure processes

Input data: Rock size distribution. Waste package barrier dimensions. Properties of waste package materials. Aging and phase stability model.

Feeds to: Stress corrosion cracking model for waste package barriers. Hydrogen induced cracking in Ti.

Responsible Organization: WPO

Due Date: 29 Sep 99

5) General Corrosion of Waste Package Barrier (W1020)

Description: This process model will address general corrosion of the waste package barrier materials. The process model for this will incorporate the following sub-models. Dry Oxidation: Models and analyses for the WP barriers for degradation process from dry oxidation, degradation rate as a function of exposure conditions, failure mode characteristics (e.g., number failure sites and opening size), and uncertainty and variability of the above degradation process.

Humid air corrosion: Models and analyses for each of the WP barriers for RH and T thresholds for corrosion initiation in the presence and absence of drips, and uncertainty and variability of the thresholds.

Aqueous corrosion: Models and analyses for each of the WP barriers for general aqueous corrosion degradation process, general aqueous corrosion rate as a function of time, failure mode characteristics (e.g., number failure sites and opening size), and uncertainty and variability of the corrosion rate.

Input data: Bounding conditions for Temperature, relative humidity and environmental conditions on the waste package surface. Project data from long-term corrosion test facility, on-going short- term electrochemical tests and published data in technical journals and handbooks.

Feeds to: Waste package degradation PMR and model abstraction for WAPDEG.

Responsible Organization: WPO

Due Date: 30 Aug 99

6) General Corrosion of the Drip Shield (W2030)

Description: The process model for this will incorporate the following sub-models. Dry Oxidation: Models and analyses for the drip shield for degradation process from dry oxidation, degradation rate as a function of exposure conditions, failure mode characteristics (e.g., number failure sites and opening size), and uncertainty and variability of the above degradation process.

Humid air corrosion: Models and analyses for the drip shield for RH and T thresholds for corrosion initiation in the presence and absence of drips, and uncertainty and variability of the thresholds.

Aqueous corrosion: Models and analyses for the drip shield for general aqueous corrosion degradation process, aqueous corrosion rate as a function of time, failure mode characteristics (e.g., number failure sites), and uncertainty and variability of the corrosion rate.

Input data: Bounding conditions for Temperature, relative humidity and environmental conditions on the drip shield surface. Project data from long-term corrosion test facility, on-going short- term electrochemical tests and published data in technical journals and handbooks.

Feeds to: Waste package degradation PMR and model abstraction for WAPDEG.

Responsible Organization: WPO

Due Date: 26 Aug 99

7) Localized Corrosion Model for Waste Package Barrier Materials (W1085)

Description: This process model will address the localized corrosion of the WP barriers including the thresholds of localized corrosion initiation in the presence and absence of drips, and uncertainty and variability of the thresholds.

Models and analyses for the WP barriers will be developed for localized corrosion degradation process, localized corrosion rate as a function of time and local corrosion conditions, failure mode characteristics (e.g., number failure sites and opening size), and uncertainty and variability of the corrosion rate.

Input data: Expected bounding conditions for Temperature, relative humidity and localized environmental conditions on the WP surface. Project data from long-term corrosion test facility, and short-term electrochemical tests currently on-going. Published literature data. Phase stability and aging model. Juvenile failures model. Data on biologic film formation.

Feeds to: Waste package degradation PMR and model abstraction for WAPDEG.

Responsible Organization: WPO

Due Date: 28 Oct 99

8) Localized Corrosion Model for the Drip Shield (W2085)

Description: This process model will address the localized corrosion of the drip shield including the thresholds of localized corrosion initiation in the presence and absence of drips, and uncertainty and variability of the thresholds.

Models and analyses for the drip shield will be developed for localized corrosion degradation process, localized corrosion rate as a function of time and local corrosion conditions, failure mode characteristics (e.g., number failure sites and opening size), and uncertainty and variability of the corrosion rate.

Input data: Expected bounding conditions for Temperature, relative humidity and localized environmental conditions on the drip shield surface. Project data from long-term corrosion test facility, and short-term electrochemical tests currently on-going. Published literature data. Phase stability and aging model (if applicable). Juvenile failures model. Data on biologic film formation.

Feeds to: Waste package degradation PMR and model abstraction for WAPDEG.

Responsible Organization: WPO

Due Date: 28 Oct 99

9) Stress Corrosion Cracking Model for Waste Package Barriers (W1075)

Description: This process model will identify the conditions under which the waste package barrier material is likely degrade by stress corrosion cracking (SCC). The model will utilize stress intensity threshold and critical flaw size approach to SCC. The model will address the likelihood of SCC as a function of T, local environment and material condition (welded, aged, annealed etc.).

Input data: Expected bounding conditions for Temperature, relative humidity and localized environmental conditions on the WP surface. Currently on-going SCC tests. Published literature data. Residual stress measurements on test welds. Juvenile failures model. Mechanical failure model.

Feeds to: Waste package degradation PMR and model abstraction for WAPDEG.

Responsible Organization: WPO (Stephen Lu, LLNL)

Due Date: 29 Oct 99

10) Stress Corrosion Cracking Model for Drip Shield (if applicable) (W3000)

Description: This process model will identify the conditions under which the drip shield material is likely degrade by stress corrosion cracking (SCC). The model will utilize stress intensity threshold and critical flaw size approach to SCC. The model will address the likelihood of SCC as a function of T, local environment and material condition (welded, aged, annealed etc.).

Input data: Expected bounding conditions for Temperature, relative humidity and localized environmental conditions on the WP surface. Currently on-going SCC tests. Published literature data. Residual stress measurements on test welds. Juvenile failures model. Mechanical failure model.

Feeds to: Waste package degradation PMR and model abstraction for WAPDEG.

Responsible Organization: WPO

Due Date: 29 Oct 99

11) Hydrogen Induced Cracking in Titanium (W3020)

Description: This process model will determine the conditions under which titanium (as a barrier or drip shield) will experience hydrogen uptake, potentially leading to embrittlement and cracking. The key parameters for this degradation mode are environment on the surface of the material, under deposits and occluded geometries and the local material condition (e.g., local defects caused by rockfall).

Input data: Environment on the surface of the material under salt and debris deposits. Mechanical failure model

Feeds to: Waste package degradation PMR and model abstraction for WAPDEG.

Responsible Organization: WPO

Due Date: 22 Oct 99

12) Degradation of Stainless Steel Structural Material (W3055)

Description: This process model will address potential degradation modes of stainless steel structural member. While this component is not intended to be a corrosion barrier, it may affect the chemistry of water entering the waste package and retard the rate of egress of the radionuclides from the breached waste package. The process model will use the expected chemistry of the crevice between the outer barrier and the stainless steel structural component and the corrosion properties of the material as the key parameters. The model will address all of the potential degradation modes (e.g. general and local corrosion and SCC).

Input data: Environment in the crevice. Project data on stainless steel corrosion. Published literature data.

Feeds to: Waste package degradation PMR and model abstraction for WAPDEG.

Responsible Organization: WPO

Due Date: 20 Oct 99

13) Waste Package Surface Chemistry (W1030)

Description: Not available at this time.

Input data:

Feeds to:
Responsible Organization: PAO

Due Date: 14 Oct 99

14) Abstraction of Mechanical Failures due to Rockfall (including seismic-induced rockfall) (WNEWF)

Description: If the process-level analysis warrants the inclusion of this degradation process in the TSPA analysis, abstraction(s) will be developed for the relationship among the thicknesses of dripshield and waste package barrier versus the rock masses that could cause damage to induce cracks and through-wall cracks. The abstraction will include potential effects of aging and microstructure changes on the mechanical properties. Uncertainty and variability of the relationship will be included in the abstraction. The abstraction results will be in a multi-dimensional lookup table and input to the WAPDEG analysis. If needed, a distribution for the size of through-wall cracks induced by rockfall will also be developed in a form that is suitable for input to the WAPDEG analysis.

Input data: Process-level analysis results for processes and parameters, including rockfall damage; through-wall crack sizes; aging and microstructure changes.

Feeds to: Waste package degradation PMR; WAPDEG analysis

Responsible Organization: PAO

Due Date: 22 Oct 99

15) Abstraction of General Corrosion of Waste Package Barrier (W1025)

Description: Abstraction(s) will be developed for important processes for general corrosion degradation of waste package barrier materials, which will include the thresholds for corrosion initiation and degradation rate. The abstractions will be in a form that is suitable for input to the WAPDEG analysis. The abstraction(s) will include, for each of the waste package barriers, 1) relative humidity and temperature thresholds for humid-air and aqueous corrosion initiation in the presence and absence of drips, and uncertainty and variability of the thresholds; and 2) aqueous general corrosion degradation process, including general aqueous corrosion rate as a function of time, temperature and other exposure conditions, failure mode characteristics (e.g., number failure sites and opening size), and uncertainty and variability of the corrosion rate.

Input data: Process-level analysis results for processes and parameters, including critical temperature threshold(s) and relative humidity threshold(s) for general corrosion initiation in the presence and absence of drips, including water chemistry evolution on waste package barriers; general corrosion rate of waste package barriers as a function of time, temperature, and other exposure conditions; geometry and size of penetrations on waste package barriers from general corrosion; uncertainty and variability of the corrosion initiation thresholds, general corrosion rate, and penetration sizes.

Feeds to: Waste package degradation PMR; WAPDEG analysis

Responsible Organization: PAO

Due Date: 30 Sep 99

16) Abstraction of General Corrosion of the Drip Shield (W2040)

Description: Abstraction(s) will be developed for important processes for general corrosion degradation of the drip shield material, which will include thresholds for corrosion initiation and degradation rate. The abstractions will be in a form that is suitable for input to the WAPDEG analysis. The abstraction(s) will include 1) relative humidity and temperature thresholds for humid-air and aqueous corrosion initiation in the presence and absence of drips, and uncertainty and variability of the thresholds; and 2) aqueous general corrosion degradation process, including general aqueous corrosion rate as a function of time, temperature and other exposure conditions, failure mode characteristics (e.g., number failure sites and opening size), and uncertainty and variability of the corrosion rate.

Input data: Process-level analysis results for processes and parameters, including critical temperature threshold(s) and relative humidity threshold(s) for general corrosion initiation in the presence and absence of drips, including water chemistry evolution on the drip shield; general corrosion rate of the drip shield as a function of time, temperature, and other exposure conditions; geometry and size of penetrations on the drip shield from general corrosion; uncertainty and variability of the corrosion initiation thresholds, general corrosion rate, and penetration sizes.

Feeds to: Waste package degradation PMR; WAPDEG analysis

Responsible Organization: PAO

Due Date: 15 Sep 99

17) Abstraction of Localized Corrosion Model for Waste Package Barrier Materials (W1090)

Description: Abstractions will be developed for pitting and crevice corrosion processes of waste package barrier materials, which will include 1) initiation threshold, 2) penetration rate as a function of time, temperature and local exposure conditions, 3) pit and crevice density, and 4) morphology and size of penetration openings. The abstractions will be in a form that is suitable for input to the WAPDEG analysis, and will include the uncertainty and variability of the above processes.

Input data: Process-level analysis results for processes and parameters, including probability of crevice formation; initiation thresholds for pitting and crevice corrosion;

local exposure conditions on the surface of each waste package barriers and in the interface between barriers; pitting and crevice corrosion rate for each barrier as a function of time, temperature and other exposure condition parameters; pit and crevice density for each barrier; morphology and size of penetration openings by pitting and crevice corrosion; effects of microstructure changes from aging of the barriers on pitting and crevice corrosion uncertainty and variability of the above processes and corrosion parameters.

Feeds to: Waste package degradation PMR
WAPDEG analysis

Responsible Organization: PAO

Due Date: 22 Nov 99

18) Abstraction of Localized Corrosion Model for the Drip Shield (W2090)

Description: Abstractions will be developed for pitting and crevice corrosion processes of Titanium-Grade-7 drip shield, which will include 1) initiation threshold, 2) penetration rate as a function of time, temperature and local exposure conditions, 3) pit and crevice density, and 4) morphology and size of penetration openings. The abstractions will be in a form that is suitable for input to the WAPDEG analysis, and will include the uncertainty and variability of the above processes.

Input data: Process-level analysis results for processes and parameters, including probability of crevice formation; initiation thresholds for pitting and crevice corrosion; local exposure conditions on the surface of each waste package barriers and in the interface between barriers; pitting and crevice corrosion rate for each barrier as a function of time, temperature and other exposure condition parameters; pit and crevice density for each barrier; morphology and size of penetration openings by pitting and crevice corrosion; uncertainty and variability of the above processes and corrosion parameters.

Feeds to: Waste package degradation PMR
WAPDEG analysis

Responsible Organization: PAO

Due Date: 3 Dec 99

19) Abstraction of Stress Corrosion Cracking Model for Waste Package Barriers (W1095)

Description: If the process-level analysis warrants the inclusion of this degradation process in the TSPA analysis, abstraction(s) will be developed for stress corrosion cracking (SCC) processes of waste package barrier materials, which will include 1) initiation threshold, 2) crack growth rate as a function of time and local exposure conditions including temperature, 3) crack density, and 4) morphology and size of crack penetration openings. The abstractions will be in a form that is suitable for input to the WAPDEG analysis, and will include the uncertainty and variability of the above processes.

Input Data: Process-level analysis results for processes and parameters, including initiation thresholds for SCC; local exposure conditions on the surface of each waste package barriers and in the interface between barriers; crack growth rate for each barrier as a function of time, temperature and other exposure condition parameters; density of cracks forming for each barrier; morphology and size of penetration openings by SCC; effects of microstructure changes from aging of the barriers on pitting and crevice corrosion; effects of manufacturing processes (including closure welds) on SCC initiation and crack growth rate; effects of rockfall (including thermal-mechanical and seismic induced) on SCC initiation and crack growth rate; uncertainty and variability of the above processes and corrosion parameters.

Feeds to: Waste package degradation PMR; WAPDEG analysis

Responsible Organization: PAO

Due Date: 22 Nov 99

20) Abstraction of Stress Corrosion Cracking Model for Drip Shield (if applicable) (W3005)

Description: If the process-level analysis warrants the inclusion of this degradation process in the TSPA analysis, abstraction(s) will be developed for stress corrosion cracking (SCC) processes of the titanium drip shield, which will include 1) initiation threshold, 2) crack growth rate as a function of time and local exposure conditions including temperature, 3) crack density, and 4) morphology and size of crack penetration openings. The abstractions will be in a form that is suitable for input to the WAPDEG analysis, and will include the uncertainty and variability of the above processes.

Input data: Process-level analysis results for processes and parameters, including initiation thresholds for SCC; local exposure conditions on the surface of the drip shield; crack growth rate as a function of time, temperature and other exposure condition parameters; density of cracks forming for the drip shield; morphology and size of penetration openings by SCC; effects of microstructure changes from aging of the drip shield on SCC; effects of manufacturing processes on SCC initiation and crack growth rate; effects of rockfall (including thermal-mechanical and seismic induced) on SCC initiation and crack growth rate; uncertainty and variability of the above processes and corrosion parameters.

Feeds to: Waste package degradation PMR; WAPDEG analysis

Responsible Organization: PAO

Due Date: 3 Dec 99

21) Abstraction of Hydrogen Induced Cracking in Titanium Drip Shield (W3030)

Description: If the process-level analysis warrants the inclusion of this degradation process in the TSPA analysis, abstraction(s) will be developed for hydrogen induced cracking (HIC) processes of the titanium drip shield, which will include 1) initiation threshold, 2) crack growth rate as a function of time and local exposure conditions including temperature, 3) crack density, and 4) morphology and size of crack penetration openings. The abstractions will be in a form that is suitable for input to the WAPDEG analysis, and will include the uncertainty and variability of the above processes.

Input data: Process-level analysis results for processes and parameters, including initiation thresholds for HIC; local exposure conditions on the surface of the drip shield; crack growth rate as a function of time, temperature and other exposure condition parameters; density of cracks forming for the drip shield; morphology and size of penetration openings by HIC; effects of microstructure changes from aging of the drip shield on HIC; effects of manufacturing processes on HIC initiation and crack growth rate; effects of rockfall (including thermal-mechanical and seismic induced) on HIC initiation and crack growth rate; uncertainty and variability of the above processes and corrosion parameters.

Feeds to: Waste package degradation PMR
WAPDEG analysis

Responsible Organization: PAO

Due Date: 24 Nov 99

22) Abstraction of Degradation Processes of Stainless Steel Structural Material (W3060)

Description: Abstractions will be developed for degradation processes of stainless steel structural member. The abstractions will include all of the important degradation processes identified by various process-level analyses (e.g. general corrosion, pitting and crevice corrosion, and SCC). The abstractions will also include, for the degradation processes identified, 1) initiation threshold, 2) penetration rate as a function of time, temperature and local exposure conditions, 3) density of corroding sites (e.g. pit density for pitting corrosion), and 4) morphology and size of penetration openings. The abstractions will be in a form that is suitable for input to the WAPDEG analysis, and will include the uncertainty and variability of the above processes.

Input data: Process-level analysis results for processes and parameters, including initiation thresholds for individual corrosion processes included in the analysis; local exposure conditions on the surface of the layer; penetration rates of individual degradation processes included in the analysis as a function of time, temperature and other exposure condition parameters; density of corroding sites (i.e., pit density crevice density, etc.); morphology and size of penetration openings by individual corrosion processes included in the analysis; effects of microstructure changes from aging of the layer on individual corrosion processes included in the analysis; uncertainty and variability of the above processes and corrosion parameters.

Feeds to: Waste package degradation PMR
WAPDEG analysis

Responsible Organization: PAO

Due Date: 6 Dec 99

23) Abstraction of Water Chemistry Evolution Inside Breached Waste Package (WNEWJ)

Description: Abstraction(s) will be developed for the evolution of exposure environments inside breached waste packages as a function of time (after initial breach of waste package), type of wastes, degradation of waste form and internal structure, and location in the repository. The abstractions will be in a form that is suitable for input to the WAPDEG analysis, and will include the uncertainty and variability of the exposure conditions.

Input data: Process-level analysis results for processes and parameters, including evolution of water chemistry inside breached waste package; temperature history inside waste package.

Feeds to: Waste package degradation PMR; WAPDEG analysis

Responsible Organization: PAO

Due Date: 30 Sep 99

24) Abstraction of WAPDEG Analysis Results for Input to TSPA Analysis (W2006)

Description: WAPDEG analysis results will be abstracted as input to the TSPA analysis. The abstractions will include the followings: 1) time-histories of waste package failures including the uncertainty of the histories; 2) time histories of the number of penetrations on waste packages including the uncertainty of the number penetrations; and 3) distribution of sizes of penetration openings on waste packages including the uncertainty of the opening sizes.

Input data: Abstractions of the degradation processes and parameters for the degradation modes included in the WAPDEG analysis. Abstraction of the waste package exposure conditions. Waste package and drip shield design data. WAPDEG analysis results.

Feeds to: Waste package degradation PMR; TSPA analysis

Responsible Organization: PAO

Due Date: 13 Jan 00

25) FEP Screening (W2007)

Description: Not available at this time.

Input data:

Feeds to:

Responsible Organization: PAO

Due Date: 1 Dec 99

26) Environment of Drip Shield Surfaces (W2055)

Description: Not available at this time.

Input data:

Feeds to:

Responsible Organization: WPO

Due Date: 30 Sep 99

27) NFE In-Drift T, H Analysis (W2075)

Description: Not available at this time.

Input data:

Feeds to:

Responsible Organization: WPO

Due Date: 2 Sep 99

			ANALYSIS AND MODEL REPORTS SUPPORTING THE WASTE FORM DEGRADATION PMR	
			Title	Resp. Org.
		1	Inventory of Commercial Spent Nuclear Fuel (CSNF)	WPO
		2	Inventory of High-Level Waste (HLW) Glass	WPO
		3	Inventory of DOE-Owned Spend Nuclear Fuel	WPO
		4	Inventory Abstraction	PAO
		5	Clad Initial Condition	WPO
		6	Clad Degradation: Temperature History	WPO
		7	Clad Degradation: FEP Screening	PAO
		8	Clad Mechanical Degradation	WPO
		9	Clad Degradation – Hydride Related	WPO
		10	Clad Degradation – Local Corrosion	WPO
		11	Clad Degradation – Dry Unzipping	WPO
		12	Clad Degradation – Wet Unzipping	WPO
		13	Clad Degradation – Summary Abstraction	PAO
		14	CSNF Waste Form Degradation: Summary Abstraction	WPO
		15	DSNF and Other Waste Forms Degradation Abstraction	WPO
		16	HLW Glass Degradation	WPO
		17	Dissolved Radionuclide Concentration Limits Abstraction	PAO
		18	Pure Phase Solubility Limits: LLNL	WPO
		19	Pure Phase Solubility Limits: LANL	NEPO
		20	Uranyl Silicate Data	NEPO
		21	Mixed Phase Dissolved Radionuclide Concentration Limits	WPO
		22	Mixed Phase Sensitivity Studies	PAO
		23	Colloid-Associated Radionuclide Concentration Limits: Abstraction and Summary	PAO
		24	Colloid-Associated Radionuclide Concentration Limits	WPO
		25	Colloid-Associated Radionuclide Concentration Limits: LANL	NEPO
		26	In-Waste Package Evaporation	WPO
		27	Basket Degradation and Waste Form Settling	WPO
		28	In-Package Chemistry: CSNF	WPO
		29	In-Package Chemistry: Co-Disposal	WPO
		30	In-Package Chemistry Summary	WPO
		31	In-Package Chemistry Abstraction	WPO
		32	In-Package Sorption	WPO
		33	In-Package Source Term and Radionuclide Transport Summary	WPO
		34	In-Package Radionuclide Transport Abstraction	PAO
		35	In-Package Source Term Abstraction	PAO
		36	WF FEPs Screening Summary	PAO

Analysis and Model Reports Supporting Waste Form Degradation PMR

1) Inventory of Commercial Spent Nuclear Fuel (CSNF) (G1005)

Description: Calculation of radionuclide content for CSNF waste packages based on input from the Waste Acceptance Department and Systems Analysis/Cost department. This inventory will be the basis for TSPA thermal calculations and radionuclide release calculations. For each arrival scenario, CSNF will be allocated to each waste package design. The number of waste packages for each waste package design in the repository will be determined. Distributions for enrichment and burn-up for each design will be developed. From these, radionuclide content distributions for each design will be developed.

Input Data: Discharge history, discharge forecasts, delivery scenarios from Waste Acceptance and Systems Analysis/Cost departments.

Feeds To: Inventory Abstraction, future NFE-TH calculations

Responsible Organization: WPO

Due Date: 19-Aug-99

2) Inventory of High Level Waste (HLW) glass (G1015)

Description: Documentation of radionuclide content for HLW glass for waste package designs.

Input Data: This work involves data qualification issues and is still being planned.

Feeds To: Inventory Abstraction, future NFE-TH calculations

Responsible Organization: WPO

Due Date: 19-Aug-99

3) Inventory of DOE Owned Spent Nuclear Fuel (G1010)

Description: Documentation of radionuclide content for all wastes other than CSNF and HLW glass. Develop short list of representative Fuels/ wastes, and perform inventory analyses for the short list. Develop probability distributions for isotope activities in DOE Spent Nuclear Fuel Packages.

Input Data: This work involves data qualification issues and is still being planned.

Feeds To: Inventory Abstraction, future NFE-TH calculations

Responsible Organization: WPO

Due Date: 19-Aug-99

4) **Inventory Abstraction (G1025)**

Description: Using input from the three WPO inventory documents, select number of distinct waste types for TSPA modeling, and the isotopes to be included in the safety case, disruptive events and human intrusion TSPA's.

Input Data: Data from referenced AP3.10Q's/QAP3-15's.

Feeds To: TSPA release calculations, future NFE-TH calculations, WF PMR

Responsible Organization: PAO

Due Date: 24-Sep-99

5) **Clad Initial Condition (G1080)**

Description: Compilation of literature data on clad condition when removed from reactor and experience of clad degradation while in storage.

Input Data: Literature

Feeds To: Clad Degradation Summary Abstraction

Responsible Organization: WPO

Due Date: 30-Sep-99

6) **Clad Degradation: Temperature History (G3080)**

Description: Using design information, calculate temperature history as a function of thermal loading and WP surface temperature. Qualified data and codes will be used.

Input Data: Design information

Feeds To: Clad Degradation: FEP Screening

Responsible Organization: WPO

Due Date: 30-Sep-99

7) **Clad Degradation: FEP Screening (G1090)**

Description: Documentation of calculations and reasoned arguments for clad degradation modes not included in the TSPA clad degradation abstraction. Literature data and results from temperature history calculation will be used to screen out modes such as: general wet or dry oxidation, creep, stress corrosion cracking, etc. Most data will be accepted.

Input Data: Literature, Clad Degradation: Temperature History, TH model results for WP surface temperatures, Inventory Abstraction temperatures, WAPDEG WP failure histories.

Feeds To: Clad Degradation: Summary Abstraction

Responsible Organization: PAO

Due Date: 1-Dec-99

8) **Clad Mechanical Degradation (G1055)**

Description: Calculations of clad disruption due to mechanical reasons such as rock fall and seismic activity.

Input Data: Data needed will include (1) design data for fuel assemblies, waste packages, and emplacement drifts, (2) seismic hazard curves, (3) mechanical properties of irradiated Zircaloy, (4) rate of emplacement drift collapse, (5) rate at which large rocks fall, (6) waste package wall thickness as a function of time, and (7) results for waste package breaching for rock impact.

Feeds To: Clad Degradation: Summary Abstraction

Responsible Organization: WPO

Due Date: 30-Sep-99

9) **Clad Degradation – Hydride Related (G1075)**

Description: Models for cladding degradation due to hydride related mechanisms, including: delayed hydride cracking (DHC), hydride reorientation and hydrogen embrittlement, etc. Perform literature review and summarize information on hydride redistribution, hydride reorientation, DHC, and hydrogen transport in concentration, temperature, and stress gradients.

Input Data: Will use literature data on hydrogen content of clad as a function of burn-up.

Feeds To: Clad Degradation: Summary Abstraction

Responsible Organization: WPO

Due Date: 30-Sep-99

10) Clad Degradation – Local Corrosion (G1070)

Description: This process model will determine the localized corrosion rate of Zircaloy cladding under the expected in-package environment. The model will address possible presence and effects of aggressive chemical species such as ferric chloride generated from the corrosion of waste package internals. Bounding conditions will be used to develop corrosion rates as a function of T and chemistry (including pH).

Input Data: Published literature data on Zircaloy corrosion under aggressive conditions

Feeds To: Clad Degradation: Summary Abstraction

Responsible Organization: WPO

Due Date: 30-Sep-99

11) Clad Degradation – Dry Unzipping (G1065)

Description: Summarize dry oxidation data with uncertainty analyses. Discuss effect of variable moisture content on air oxidation of CSNF. Summarize available literature on clad unzipping. Develop and report a simple model with uncertainty analyses for the time to initiate clad unzipping due to air oxidation as a function of temperature.

Input Data: Project generated data reported here. Literature

Feeds To: Clad Degradation: Summary Abstraction

Responsible Organization: WPO

Due Date: 30-Sep-99

12) Clad Degradation – Wet Unzipping (G1060)

Description: Summarize available data with uncertainty analyses on impact of wet fuel alteration on cladding. Develop and report a simple model with uncertainty analyses for the clad unzipping due to wet fuel alteration. Report on planning and progress of testing of unirradiated UO_2 or fuel in vapor and drip tests under accelerated conditions to verify models. Most data will be accepted or corroborative.

Input Data: Literature

Feeds To: Clad Degradation: Summary Abstraction

Responsible Organization: WPO

Due Date: 30-Sep-99

13) Clad Degradation – Summary Abstraction (GNEWA)

Description: Combine all clad degradation models with In-WP temperature history and geochemistry results to produce models of history of containment and surface area. Discuss validation of abstraction and other views not already discussed.

Input Data: Clad degradation AP3.10Q's and QAP3-15's

Feeds To: TSPA release calculations, WF PMR

Responsible Organization: PAO

Due Date: 30-Sep-99

14) CSNF Waste Form Degradation: Summary Abstraction (G2030)

Description: Summary description of all available data, including: 1) Inventory distribution within fuel, 2) Flow through experiments, 3) Unsaturated Drip Tests, 4) Batch tests, 5) Electrochemical Tests, 6) Natural Analogues. Discuss mechanistic implications of data. Include discussion of all processes indicated in the CLST IRSR. Present justification for selection of flow-through data as the basis of an empirical bounding model.

Input Data: CSNF Waste Form Degradation: Flow-Through Data, Unsaturated Drip Tests, Literature

Feeds To: TSPA release calculations, WF PMR

Responsible Organization: WPO

Due Date: 10-Dec-99

15) DSNF and Other Waste Forms Degradation Abstraction (G2080)

Description: Description of degradation of other waste forms including DOE SNF, Navy SNF, Pu Disposition wastes. Each waste type will be described covering the same issues as covered for CSNF as applicable, including: special inventory issues such as unusual inventory or inventory distribution, clad or canister degradation models as applicable, waste form degradation including surface area, and other issues specific to the waste form such as pyrophoricity. NSNFP alteration rate data for MOX, U, UAl_x, and C SNF will be used as available. Justification of the use of representative waste degradation rates and bounding models for the base case.

Input Data: EM data, EM documents, literature data (EM documents will be prepared under AP3.10Q and will be delivered to EM checking in July and August 1999.)

Feeds To: TSPA release calculations, WF PMR

Responsible Organization: WPO

Due Date: 8-Nov-99

16) HLW Glass Degradation (G2050)

Description: Develop alteration rate models of HLW glass under vapor and aqueous conditions, including the effects of glass composition, solution chemistry, and a discussion of the surface area undergoing active degradation within a defected pour canister. Abstraction of above into one or two models for degradation of glass under aqueous and vapor conditions. Discussion of data QA and validation of abstraction(s), natural analogues, other views.

Input Data: Project results and literature data

Feeds To: TSPA release calculations, WF PMR

Responsible Organization: WPO

Due Date: 30-Sep-99

17) Dissolved Radionuclide Concentration Limits Abstraction (G3025)

Description: Summary of dissolved concentration limits to be used in TSPA. Provide dissolved phase concentration distribution or function of in-WP chemistry for all elements. As needed, these may be taken directly from the pure and mixed-phase analyses, or may result from additional analysis documented here.

Input Data: Pure and mixed phase concentration limit AP3.10's

Feeds To: TSPA release calculations, WF PMR

Responsible Organization: WPO

Due Date: 6-Dec-99

18) **Pure Phase Solubility Limits LLNL(G3020)**

Description: Develop pure phase solubility distributions or models as f(In-WP chem.) as applicable. Some elements may have separate AP3.10Qs. Elements to include: U, Pd, Am, Pa, C, I. Discussion to include, uncertainty, validation, abstraction, abstraction validation, results, data QA and other views.

Input Data: NEA, Literature

Feeds To: Summary Dissolved Radionuclide Concentration Limits

Responsible Organization: WPO

Due Date: 30-Sep-99

19) **Pure Phase Solubility Limits: LANL (G3015)**

Description: Develop pure phase solubility distributions or models as f(In-WP chem.) as applicable. Some elements may have separate AP3.10Qs. Elements to include: Tc, Np, Pu. Discussion to include, uncertainty, validation, abstraction, abstraction validation, results, data QA and other views.

Input Data: NEA, Literature

Feeds To: Summary Dissolved Radionuclide Concentration Limits

Responsible Organization: NEPO

Due Date: 30-Sep-99

20) **Uranyl silicate data (G3000)**

Description: Compilation and evaluation of thermodynamic data for uranyl silicate phases.

Input Data: Literature

Feeds To: Summary Dissolved Radionuclide Concentration Limits

Responsible Organization: NEPO

Due Date: 30-Sep-99

21) Mixed Phase Dissolved Radionuclide Concentration Limits (G3010)

Description: Describe paragenetic sequence(s) of uranium solids formed during corrosion and dissolution experiments with spent nuclear fuels and unirradiated UO_2, as well as evidence from natural uranium-mineral occurrences, and through geochemical modeling efforts. Describe what radionuclides go into uranium corrosion products. Based primarily on ANL drip and vapor tests, provide: (1) a quantitative description of Np incorporation in U-solids; (2) a qualitative discussion of Tc, Pu, I, Se, Am, Pa, C and possibly additional elements emphasized by PA, as data allow. Provide preliminary experimental data of Np-U coprecipitation in solid phases.

Input Data: Literature, Project data

Feeds To: Summary Dissolved Radionuclide Concentration Limits

Responsible Organization: WPO

Due Date: 30-Sep-99

22) Mixed Phase Sensitivity Studies (G3005)

Description: Derive AREST-CT inputs from the thermochemical properties of reactions based on GEMBOCHS database. Evaluate kinetic data for spent fuel and uranyl minerals. Model Np and U concentration sensitivities under repository conditions based on compiled thermodynamic data, kinetic data, range of flow rates, clad model, and water contact scenario. Model ANL's drip tests for model validation. Document the QA status of the inputs and assumptions and determine if sensitivity study results may be used for more than confirmatory purposes.

Input Data: Literature, Project data

Feeds To: Summary Dissolved Radionuclide Concentration Limits

Responsible Organization: PAO

Due Date: 30-Sep-99

23) Colloid-Associated Radionuclide Concentration Limits: Abstraction and Summary(G3050)

Description: Document selection of radionuclides (RNs) for which colloid assisted transport are important to system performance. Summarize mechanisms of formation, stability, RN attachment/detachment, and colloid assisted transport within the waste package. Develop and justify abstraction of information for use in RIP calculations. Combine with in-WP chemistry and derived solubilities to obtain colloid-associated RN concentration limits. Compare predicted concentration range with observed concentrations from drip and batch tests, and natural and anthropogenic analogues.

Input Data: Literature, Project reports, Colloid AP3.10Q's

Feeds To: TSPA release calculations, WF PMR

Responsible Organization: WPO

Due Date: 13-Dec-99

24) Colloid-Associated Radionuclide Concentration Limits: ANL (G3040)

Description: Summarize all ANL work on colloid-associate radionuclide concentration limits. Interpret available experimental data to identify and document mechanisms of formation. The experimental data on waste form colloids from ANL will include TEM, DLS, and sequential filtration measurements. Identify and document mechanisms of stability over a range of environmental conditions (i.e., pH, ionic strength, cations). Document stability data on colloids generated from ANL waste form corrosion tests. Colloids will be generated from waste form corrosion tests conducted at ANL. The colloids will be shipped to LANL for disassociation studies. Develop compendium of waste form colloids to include experimental data, and field and natural analogues.
Input Data: Reported here

Feeds To: TSPA release calculations

Responsible Organization: WPO

Due Date: 30-Sep-99

25) Colloid-Associated Radionuclide Concentration Limits: LANL (G3035)

Description: Develop a colloid concentration model. Identify and document mechanisms of formation. This will be done for several colloids types: waste-derived colloids, intrinsic colloids, pseudo-colloids. The effects of groundwater chemistry (in particular, ionic strength and pH) and temperature will be evaluated. Identify and document mechanisms of stability. Identify and document mechanisms of attachment/detachment. Sorption and desorption as a function of time will be measured for natural and man-made-material-derived colloids (hematite, goethite, smectite, silica) and radonuclide colloids (colloidal Pu(IV) and soluble Pu(V). Model input to TSPA will be provided, Determine attachment/detachment rates for Pu (IV), Pu (V), and Am onto clay, iron-oxide, and silica in J-13 and P-1 waters (high-pH sodium carbonate/bicarbonate synthetic groundwater). Determine detachment rates for RNs from waste-derived colloids (based on experimental data provided by ANL). Report natural and anthropogenic data on colloids and colloid transport.

Input Data: Reported here, Literature

Feeds To: TSPA release calculations

Responsible Organization: NEPO

Due Date: 30-Sep-99

26) In-WP Evaporation (GNEWB)

Description: Calculations of amount of water that may be evaporated from WP heat.

Input Data: Power curves, WP surface temperature curves

Feeds To: In-Package Chemistry, In-Package Source Term and Radionuclide Transport Abstraction

Responsible Organization: WPO

Due Date: 30-Sep-99

27) Basket Degradation and Waste Form Settling (G3090)

Description: Description and calculation of basket degradation and waste form settling scenarios.

Input Data: WP models, Literature

Feeds To: In-Package Source Term and Radionuclide Transport Summary

Responsible Organization: WPO

Due Date: 30-Sep-99

28) In-Package Chemistry: CSNF (G3060)

Description: Calculation of in-package chemistry for CSNF packages based on in-package chemistry model documented in the In-Package Chemistry Summary AP3.10Q.

Input Data: package, clad and waste degradation rates, literature

Feeds To: In-Package Chemistry Summary

Responsible Organization: WPO

Due Date: 9-Nov-99

29) In-Package Chemistry: Co-Disposal (G3070)

Description: Calculation of in-package chemistry for co-disposal packages based on in-package chemistry model documented in the In-Package Chemistry Summary AP3.10Q. Data qualification issues still being planned.

Input Data: package, clad and waste degradation rates, literature

Feeds To: In-Package Chemistry Summary

Responsible Organization: WPO

Due Date: 3-Dec-99

30) In-Package Chemistry Summary (G3075)

Description: Introduction to in-package chemistry modeling. Description of processes, uncertainties, and modeling methodology. Discussion of Issues from Evolution of Near Field Environment KTI. Links to other process models and PMRs (fuel dissolution, clad, basket and WP degradation, seepage, etc.). Summary of CSNF and Co-disposal calculations and results.

Input Data: In-Package Chemistry AP3.10Q's, literature

Feeds To: In-Package Chemistry Abstraction

Responsible Organization: WPO

Due Date: 27-Jan-00

31) In-Package Chemistry Abstraction (GNEWD)

Description: This model will be used in the probabilistic total system performance assessment (TSPA) to quantify the time-dependent chemical environment in the waste package. This model abstracts the combined effects of important chemical processes that can occur in the waste package. Chemical interactions inside the package between seepage and corrosion products from steel corrosion and waste form degradation will be included. This abstraction model also takes into account uncertainties in flux and composition of seepage entering the package and uncertainties in chemical reactions and reaction rates.

Input Data: Results from In-Package Chemistry Summary

Feeds To: TSPA release calculations, WF PMR

Responsible Organization: WPO

Due Date: 1-Dec-99

32) In-Package Sorption (G3085)

Description: Discussion of in-package sorption. Justification for selected TSPA parameter ranges will be documented.

Input Data: TBD

Feeds To: In-Package Source Term and Radionuclide Transport Summary

Responsible Organization: WPO

Due Date: 30-Sep-99

33) In-Package Source Term and Radionuclide Transport Summary (G3095)

Description: This document combines all the pieces of the source term and radionuclide transport process models into an integrated whole. It also uses the temperature results from TH modeling, the package degradation history from WP modeling, and the seepage from the EBS modeling, as available. If new versions of these results are unavailable, it will use preliminary results or TSPA-VA results. It includes discussion of the chemical and physical state of the package internals, contact of waste with seepage flow and water vapor, waste form degradation and clad degradation, dissolved and colloidal concentration limits. Validation using unsaturated drip and batch tests will be discussed. Other views will be discussed.

Input Data: WF AP3.10Q's, WP results, TH results, EBS results

Feeds To: In-Package Source Term Abstraction and In-Package Radionuclide Transport Abstraction

Due Date: 29-Dec-99

ANALYSIS AND MODEL REPORTS SUPPORTING THE ENGINEERED BARRIER SYSTEM PMR		
	Title	Resp. Org.
1	Physical and Chemical Environment Model	EBSO
2	Seepage/Invert Interactions	PAO
3	Microbial Communities	PAO
4	Seepage/Backfill Interactions	PAO
5	Precipitates/Salts Analysis	PAO
6	Corrosion Products	PAO
7	In-Drift Gas Flux & Composition	PAO
8	In-Drift Colloids & Concentrations	PAO
9	Seepage/Cement Interactions	PAO
10	In-Drift T-H-C Analyses	EBSO
11	EBS Physical and Chemical Environment Abstraction	PAO
12	Water Distribution & Removal Model	EBSO
13	Performance of Diversion Features	EBSO
14	Performance of Drainage Features	EBSO
15	Ventilation Model	EBSO
16	Drift Stability	EBSO
17	Water Distribution & Removal Abstraction	PAO
18	EBS Radionuclide Migration Process Model	EBSO
19	Invert Diffusion Properties Model	EBSO
20	EBS Radionuclide Migration Abstraction	PAO
21	EBS FEPS/Degradation Mode Analysis	EBSO
22	EBS FEPS/Degradation Modes Abstraction	PAO
23	PCE Model Valid Expert/Analysis	EBSO

Summary Descriptions of AP-3.10Q Models and Analyses for theAnalyses and Model Reports Supporting the EBS Engineered Barrier System Degradation Process Model Report

1) Physical and Chemical Environment Model AP-3.10Q (EB35) RPPM100A

Description: The principal objective for the Physical and Chemical Environment Model is to evaluate changes in aqueous chemistry and gas-phase composition resulting from interaction of introduced materials and heat, with water seeping into the drift, taking into account variability in seepage and drainage fluxes, the effects of temperature changes on chemical equilibria and rate processes, and physical processes such as evaporation and condensation. In addition, this report will include evaluation of the effects of rockfall debris on the physical and chemical environment in the emplacement drifts.

This report will describe the available data used to develop and support the model, and the attendant uncertainties and limitations. Summaries of relevant project reports (e.g. AP-3.10Q reports) will be included where they provide information on testing and other data sources. Qualified and non-qualified project data (clearly identified), and data from the open literature (clearly identified), will be included in this discussion.

This report will describe the assumptions related to the development and use of the Physical and Chemical Environment Model, and which apply to its application for predicting repository conditions. It will also describe the conceptual basis for predicting the in-drift physical and chemical environment, and how alternative conceptual models were evaluated. Using the conceptual basis, analytical and numerical models for EBS environmental conditions will be developed where appropriate.

The objective of the Physical and Chemical Environment (P/CE) Model is to determine the changes in water chemistry resulting from the interaction of introduced materials with water seeping into the drift, taking into account the variation in seepage and drainage fluxes, the effects of temperature changes on chemical equilibria, and physical processes such as evaporation and condensation. The EBS Physical and Chemical Environment Model requires input from the NFE PMR for the chemistry of water entering the drift, and the extant gas phase composition, as a functions of time. In addition, EB155, the EBS Water Distribution and Removal Model will, provides in-drift flow fields, and data for the water fluxes contacting different EBS elements such as the drip shield and the invert. The EBS Drift Stability Model will provide information on the timing and nature of rockfall.s.

Results from the EBS Physical and Chemical Environment Model will be used primarily as input for abstraction of the in-drift chemical environment in TSPA. Results will also be used by the WP and WF Process Models to evaluate the nature and rates of waste package and waste form degradation, and by the EBS Radionuclide MigrationTransport

Model to represent the environmental conditions that affect transport, and by the NFE PMR to evaluate whether sources or sinks of gas-phase constituents in the EBS have a significant effect on gas composition.

The report will be revised as additional qualified test data become available. The P/CE model comprises two groups of supporting models and analyses. The first group includes chemical models and analyses that may be directly abstracted for TSPA. This group includes: Seepage/Invert Interactions, Microbial Communities, Seepage/Backfill Interactions, Precipitates/Salts Analysis, Corrosion Products, In-Drift Gas Flux & Composition, In-Drift Colloids & Concentrations, and Seepage/Cement Interactions. The second group includes in-drift process models that need to be integrated into the P/CE process model prior to abstraction. This group includes: In-drift T-H-C, Drift Stability and Ventilation. Because these models support both the P/CE model and the Water Distribution and Removal Model, only models from the first group and the In-drift T-H-C model will be described under the P/CE Model. Models of both groups will be abstracted within the P/CE Model Abstraction Effort. Additional analyses or model features may alsowill have to be added if design changes affect the configuration oradd or delete any types of materials present within the EBS. For example, if Portland cement grout is not used, its effect on seepage water chemistry is not relevant.

Input Data: Laboratory Experimental Test Data, Geochemical GEMBOCHS Database from NFE PMR, EBS Design Input, EBS Pilot-Scale Test Resultss, EBS AP-3.10Q process model report for Water Distribution and Removal ModelNF PMR, WP PMR, WF PMR.

Feeds To: Gaseous and Aqueous phase compositions to WP PMR, WF PMR, NFE PMR. Potential source/sink changes to gas phase composition, to NFE PMR. In-drift chemical environment and mobile-phase composition information to the AP-3.10Q process model report for the EBS Radionuclide Migration Model.

Responsible Organization: EBSO

Due Date: 2 Dec 99

2) Seepage/Invert Interactions AP-3.10Q (EB215) RPPM035A

Description: This abstraction model will evaluate the effect on water chemistry, of chemical reactions between water that enters the drift and invert materials in the drift. These materials may or may not have a mineralogical makeup that is similar to the host rock. If they are not similar, changes in water chemistry are likely to occur. These changes may affect the transport of radionuclides through the invert, and the chemistry changes comprise part of the input needed for the EBS Radionuclide Transport Model.

Input Data: EBS Design Input , EBS Tests, NF PMR,WP PMR, WF PMR

Feeds To: EBS Physical/Chemical Environment Abstraction ModelChemical interaction between seepage and invert, to WP PMR, WF PMR, NF PMR

Responsible Organization: PAO

Due Date: 30 Aug 99

3) Microbial Communities AP-3.10Q (EB185) RPPM020A

Description: This abstraction model analysis will bound the ultimate abundance of microbes within the drift environment using an approach that evaluates nutrient and energy limitations within the drift. Changes in microbee abundance due to thermal loading and introduced materials will also be considered. Microbe abundance may affect WP waste package lifetime and the generation of colloids capable of transporting radionuclides.

Input Data: EBS Design, NF PMR Input

Feeds To: Microbe mass estimate and assessment, to WP PMR, WF PMR, NF PMR, EBS Physical/Chemical Environment Abstraction Model

Responsible Organization: PAO

Due Date: 14 Sep 99

4) Seepage/Backfill Interactions AP-3.10Q (EB165) RPPM015

Description: This abstraction model willnalysis evaluates the effect on water chemistry of chemical reactions between water that enters the drift and backfill materials in the drift. These materials may or may not have a mineralogical makeup that is similar to the host rock. If they are not similar, changes in water chemistry are likely to occur. These changes may affect drip shield and WP/WF performance, and represent data needed by WP and WF.

Input Data: EBS Design Input, EBS Tests, NF PMR

Feeds To: Chemical interaction between seepage and backfill, to WP PMR, WF PMR, NF PMR, EBS Physical/Chemical Environment Abstraction Model

Responsible Organization: PAO

Due Date: 16 Aug 99

5) Precipitates/Salts Analysis AP-3.10Q (EB45) RPPM105A

Description: This abstraction model will evaluate the types and amounts of precipitates (including salts) that may form as water is boiled within the drift. The analysis will assesses the effects on water chemistry of accumulated mass of precipitates, the time and relative humidity controls on water vapor condensation, and the dissolution of precipitates/salts previously deposited on waste package and other EBS component surfaces. The evaluation will include changes in concentration of aqueous solutions resulting from evaporation driven by temperature gradients within the drift (e.g., from package surface to drift wall). Mixing of seepage water with this concentrated water will beis considered evaluated in order to evaluatdetermine thehow much time is required for concentrations to return to ambient levels.

Input Data: EBS Design, EBS Tests, NF PMR Input

Feeds To: EBS Physical/Chemical Environment Abstraction ModelWP/WF PMR, NF PMR

Responsible Organization: PAO

Due Date: 7 Oct 99

6) Corrosion Products AP-3.10Q (EB135) RPPM010A

Description: This abstraction model includes evaluation of chemical reactions between the aqueous seepage that enters the drift and metallic components and their corrosion products encountered along the flow paths. These components may include the ground support system, a drip shield, the waste package, the internal waste package structures, the waste package supports, the rail system, and possibly the invert materials.

Input Data: EBS Design, EBS Tests, NF PMR, WP PMR (Corrosion Rates), WF PMR Input

Feeds To: EBS Physical/Chemical Environment Abstraction Model, WP PMR, WF PMR, NF PMR

Responsible Organization: PAO

Due Date: 20 Aug 99

7) In-Drift Gas Flux & Composition AP-3.10Q (EB175) RPPM055A

Description: This abstraction will evaluate changes in gaseous phase composition within the emplacement drifts through time arising from the thermal perturbation of the geosphere and reactions of ambient gases with introduced materials. The analysis will include, at a minimum, the concentrations of the following constituents: carbon dioxide, oxygen, nitrogen, and steam. Major processes will include the boiling of the water in the emplacement drifts, and possible chemical interactions between the water-gas-materialswater, gas, and solid phases in the emplacement drift that may act as sources or sinks for constituents in the gas phase. Incoming gas model will be developed to represent for boundary conditions on the emplacement drifts, with consideration of advective and diffusive transport of gas constituents from both water seeping into the drift and from water that is just outside the drift in the geosphere. Mass balance considerations for the major potential sinks of both oxygen and carbon dioxide will be evaluated to assess whether these may affect the gas composition within the drift relative to the rates at which these constituents are supplied to the drift.

Input Data: GEMBOCHS data, EBS Design Input, Geochemical Database from the NFE PMR, EBS Tests, NF PMR, WP/NF PMR

Feeds To: EBS Physical/Chemical Environment Abstraction Model Gaseous phase composition; WP PMR, WF PMR, NF PMR

Responsible Organization: PAO

Due Date: 4 Oct 99

8) In-Drift Colloids & Concentrations AP-3.10Q (EB195) RPPM025A

Description: This submodel abstraction model and analysis will describeprovides a description of the types of colloids that may result from the introduced materials within the, as well asand the natural colloids that have entered are likely to enter the drift with seepage. Concentrations of these colloid types will beare based on stability relations for colloids as a function of the concentration of dissolved constituents within the water.

Input Data: EBS Design Input

Feeds To: EBS Physical/Chemical Environment Abstraction Model; Colloid Concentrations distributions to WP/WF PMR, NF PMR, UZ PMR

Responsible Organization: PAO

Due Date: 29 Oct 99

9) Seepage/Cement Interactions AP-3.10Q (EB208) RPPM030A

Description: This submodel and analysis model will evaluate the evaluation of aqueous phase chemical reaction of seepage that has entered the drift with cementitious materials that are initially in equilibrium with the In-Drift Ggaseous phase. The reaction can cause the gaseous gas phase composition to change if the reservoir of gas available for reaction within the drift is depleted. Relative reaction rates are will be used to represent the differential reaction rates of the distinct phases assumed to be present in the cementitious materials within concrete.

Input Data: GEMBOCHS data, EBS Design, EBS Tests, NF PMR Input, Geochemical Database from the NFE PMR

Feeds To: EBS Physical/Chemical Environment Abstraction Model; WP PMR, WF PMR, NF PMR

Responsible Organization: PAO

Due Date: 18 Oct 99

10) In-Drift T-H-C Analyses AP-3.10Q (EB225) RPPM065A

Description: This EBS process sub-model and analysis will address the combined effects of thermal (T), hydrological (H), and chemical (C) processes to evaluate the distribution of the partitioned flow inside the emplacement drift. The report is currently planned to first model the thermal (T) environment, then model the coupled T-H environment, and subsequently model the effects of coupled T-H-C processes.

The In-Drift T-H-C submodel will evaluate the flow partitioning of water (and water vapor) that originates as seepage inflow, as it flows through the EBS components of the multiple-barrier system. These components include the drip shield, the invert, rubble from drifta collapsed drift, and engineered backfill. The input to this submodel will includes the unsaturated hydrological, thermal, and chemical properties of the component materials. The analysis will also include an evaluation of the chemical alteration of individual components, and how such alteration would alter the hydrological and the thermal properties of components, as applicable. The results of the model will include the partitioned flows for drip shield diversion, drip shield imbibition, hydrologic conditions in the invert imbibition, drip shield evaporation, and natural convection and condensation/evaporation effects under the drip shield.

Input Data: Laboratory Experimental Test Data, EBS Design Input, EBS Pilot-Scale Test Results, NFE PMR

Feeds To: AP-3.10Q process model reports for the EBS Water Distribution and Removal Model, and the EBST/RH bounds/thresholds and THC environments to: WP PMR, WF PMR, NF PMR Physical and Chemical Environment Model

Responsible Organization: EBSO

Due Date: 29 Oct 99

11) EBS Physical and Chemical Environment Abstraction AP-3.10Q (EB115) RPPM040A

Description: The abstraction in this model will be based on the results of the EBS Physical and ChemicalP/ ProcessCE Model, and the supporting EBS abstraction models described above. This AP-3.10Q report will develop an integrated predictive modeling capability based on EQ3/6, results from which will then be implemented directly within the TSPA-SR/LA calculations using the RIP model.

Input Data: EBS AP-3.10Q Analyses Physical and Chemical Environment Process Model, and EBS AP-3.10Q abstraction models

Feeds To: TSPA

Responsible Organization: PAO

Due Date: 29 Dec 99

12) Water Distribution & Removal Model AP-3.10Q (EB155) PPM0R50A

Description: This model comprises the following supporting models and analyses; In-Drift THC Analyses (see 10 above, under the P/CE Model), Performance of Diversion Features, Performance of Drainage Features, Ventilation Model, and Drift Stability. Under some conditions, liquid water will seep into emplacement drifts through fractures in the host rock and move generally downward, potentially contacting waste packages. After waste packages are breached by corrosion, some of this seepage water will contact waste, dissolve or suspend radionuclides, and ultimately carry radionuclides through the EBS to the near-field host rock.

Lateral diversion of liquid water within the drift will occur to some extent at the inner drift surface, and more importantlysignificantly from the operation of engineered structures such as drip shields, capillary barriers, and the outer surface of thea penetrated waste package. If most of the seepage flux can be diverted laterally and removed from the drifts before contacting waste, the rate of radionuclide escape from the EBS can be limited, resulting in a proportional reduction in dose release at the accessible environment.

This process model will quantify the fraction of liquid water entering the drift that willcan be prevented from contacting waste by the combined effects of engineered controls on water distribution and removal. The approach willmust be flexible yet detailed enough to analyze different design solutions for water diversion, such as drip shields alone, drip shields with backfill, and capillary barriers with or without drip shields. Water can be removed during preclosure operation by evaporation from ventilation, and after closure by drainage into the fractured host rock. Engineered drain holes may be required to assure that adequate drainage survives the thermal pulse.

This EBS process model will comprise the following EBS supporting models and analyses: In-Drift THC Analysis, Performance of Diversion Features, Performance of Drainage Features, Ventilation Model, and Drift Stability Model. Processes will include heat transfer by radiation, convection, and conduction, phase changes (vaporization and condensation), and THC coupled processes that may change flow pathways within the EBS. This model will receive input on Supporting models include isothermal and thermally perturbed seepage, and THC fracture plugging above and below the emplacement drifts, from the NFE and UZ PMRs.

Input Data: Laboratory Experimental Test Data, EBS Design Input, EBS Pilot-Scale Tests, NFE PMR, (seepage data) WP UZ PMR (DS and WP data)

Feeds To: Water flow partitioning rates; EBS AP-3.10Q process model reports for EBS Radionuclide Migration and EBS Physical and Chemical Environment; also the AP-3.10Q Water Distribution and Removal Abstraction report

WP PMR, WF PMR, NF PMR

Responsible Organization: EBSO

Due Date: 2 Dec 99

13) Performance of Diversion Features AP-3.10Q (EB235) RPPM085A

Description: This EBS process sub-submodel will include, at a minimum, bounding analyses for the flow pathways of liquid water through the EBS. Analyses Needed analyses are required forinclude evaluation of the amounts of lateral and vertical liquid flow of liquid waterflow (both condensation and seepage) at keya number of locations within the EBS:

- At tlhe inner surface of the emplacement drift wall
- At both tUhe upper and lower surfaces of drip shields
- Within backfill, including capillary barriers and/or rockfall debris
- Through holes in drip shields and waste packages
- Through the EBS to the unexcavated host rock.

Input Data: Laboratory Experimental Test Data, EBS Design Input, EBS Pilot-Scale Tests, NFE PMR (flux data), WP PMR and WF PMR (WP temps and degradation modes)

Feeds To: Water flow patitioning, rates to WP PMR, WF PMR, NF PMREBS AP-3.10Q process model report for Water Distribution and Removal Model

Responsible Organization: EBSO

Due Date: 29 Oct 99

14) Performance of Drainage Features AP-3.10Q (EB227) RPPM070A

Description: This EBS process sub-submodel will addresses the analysis and design requirements of drainage features, such as gravel-packed or hydro-fractured drain holes or sumps, for which the need may become apparent as a result of ESF drainage studies and In-drift T-H-C analyses. The inputs to the model include the drainage characteristics of the fracture system and THC alterations to the drainage capacity of the host rock below the drifts. If it becomes necessary to include drainage features, this submodel will address the selection of the geometry and unsaturated flow properties of EBS materials needed to design these features, to assure removal of water from the drifts. In addition, the potential radionuclide retardation characteristics of these materials will be considered.

Input Data: Laboratory Test Data, EBS Design Input, EBS Pilot-Scale Tests, EBS Radionuclide Migration process model AP-3-10Q report, NFE PMR (flux data)

Feeds To: EBS AP-3.10Q analysis and model report for Water Distribution and Removal Model, NFE PMR, UZ PMR

Responsible Organization: EBSO

Due Date: 29 Oct 99

15) Ventilation Model AP-3.10Q (EB229) RPPM075

Description: This EBS process sub-submodel and analysis will addresses the heat and mass transfer that takes place due to repository forced air ventilation during the pre-closure phase, and due to natural ventilation through the open and partially closed drifts during the post-after closure phase. The inputs to the model include the pre-closure forced forced air flow rate(s), and the free air ventilation flow rates, heat generation characteristics of the waste packages, EBS Design input, ands well as the thermal-hydrologic properties of the host rock properties of water vapor and air. The analysis will develop a response surface for heat and mass transfer that can beis used in conjunction with other analyses to evaluate repository temperature and hydrologic effects.

Input Data: EBS Design Input, EBS Pilot-Scale Tests, NFE PMR, WP PMR

Feeds To: EBS AP-3.10Q analysis and model report for Water Distribution and Removal ModelWP PMR, WF PMR, NF PMR, NFE PMR

Responsible Organization: EBSO

Due Date: 29 Oct 99

16) Drift Stability AP-3.10Q (EB231) RPPM080A

Description: Within some time period after closure, degradation of the ground support system will allow the emplacement drifts to partially collapse, changing the drift profile and depositing rubble on the water diversion structures, drip shields, or waste packages. The change in drift profile can be usedis required by the NFE PMR to recalculate seepage flux into the drift, and the thermohydrologic and other properties of the rubble are needed. This EBS process sub-model AP-3.10Q report will provide an "end-point" drift configuration reached when it is no longer possible for a matrix block to fall, either because roof blocks are locked in place by other immobile blocks or because the drift has bulked full. The time of collapse will be based on simple criteria to be developed, such as the time at which the drift cools to a specific temperature after reaching its peak temperature.

Existing fracture mapping data obtained for key-block analysis will be used to generate random samples by pulling out key blocks until the crown is geometrically stable, or until the drift is bulked full. A smooth curve (such as an ellipse) will be developed by a least-squares fit to the resulting irregular profile, and characterized by its parameters (major axis, minor axis, and direction of major axis). Repeated sampling will provide probability distributions for the parameters for the smooth curves. The residual obtained by subtracting the smooth curve from the rough profile will be used to develop a probability distribution for the surface roughness. The resulting distributions of smooth-curve parameters and surface roughness will be input to the drift-scale seepage models under both ambient and thermally perturbed conditions. Particle size distributions for the rubble will also be estimated and used to estimate its thermal-hydrologic properties.

Input Data: Rock properties and fracture mapping data, EBS Design Input, EBS Pilot-Scale Test Resultss, NFE PMR Input

Feeds To: Rock size distribution and, drift profile information to the: WP PMR, NFE PMR, Tectonics PMR, and UZ PMR

Responsible Organization: EBSO

Due Date: 14 Sep 99

17) Water Distribution & Removal Abstraction AP-3.10Q (EB245) RPPM090A

Description: The abstraction will be based on the result of the corresponding process model analysis and will be implemented directly within the TSPA-SR/LA calculations using the RIP model.

Input Data: EBS AP-3.10Q Water Distribution and Removal Process Model Report, also other EBS abstraction model AP-3.10Q reports.

Feeds To: TSPA

Responsible Organization: PAO

Due Date: 29 Dec 99

18) EBS Radionuclide Migration Process Model AP-3.10Q (EB205) RPPM060A

Description: This report will provide a description of the radionuclide transport within the emplacement drift invert and drainage features, resulting from waste form releases out of one or more degraded waste packages. The radionuclide transport description will include advective and diffusive transport as well as the potential for retardation due to sorption and precipitation. The analysis will be based on radionuclide release input data from the WP and WF PMRs, as well as flow fields and data from the EBS Water Distribution and Removal Model, and information from the EBS Physical and Chemical Degradation Mode Model. A model for solute diffusion behavior of invert materials will be used as input to this report predictive model for diffusion coefficients for invert material will be developed (see 19 below) to support material selections EBS testing and the invert transport analysis. Experimental solubility, dispersivity and sorption data will be developed to (depending on funding) may support the analysis. The NUFT and other codes will support the analysis. This analysis will provide input data, including breakthrough curves in response to a unit release of radionuclides from the waste package, to the EBS Radionuclide Migration Abstraction. Near Field and Unsaturated Zone PMRs.

Input Data: Laboratory Test Data, EBS Design Input, EBS Tests, EBS Water Distribution and Removal Model, EBS Physical and Chemical Environment ModelNF PMR (Flux Data), WP PMR, NF PMR

Feeds To: EBS Radionuclide Migration Abstraction AP-3.10Q report. Radionuclide transport data to: NF PMR, UZ PMR

Responsible Organization: EBSO

Due Date: 2 Dec 99

19) Invert Diffusion Properties Model AP-3.10Q (n/a) RPPM120A

Description: This model will be developed based on analytical models of diffusion behavior, literature survey of material properties, as well as experimental and qualified test data. The model will be used to support invert material selection and testings.

Input Data: Laboratory Experimental Test Data, EBS Design Input, EBS Pilot-Scale Tests, NF PMR (Flux data), WP/NF PMR

Feeds To: EBS Tests, NF PMRRadionuclide Migration Process Model

Responsible Organization: EBSO

Due Date: 14 Sep 99

20) EBS Radionuclide Migration Abstraction AP-3.10Q (EB255) RPPM095

Description: The abstraction will be based on the results of the corresponding process model analysis (EB205) and will be implemented directly within the TSPA-SR/LA calculations using the RIP code.

Input Data: EBS AP-3.10Q analysis and model report for EBS Radionuclide Migration Model, also other EBS abstraction model AP-3.10Q reports.

Feeds To: TSPA

Responsible Organization: PAO

Due Date: 29 Dec 99

21) EBS FEPS/Degradation Mode Analysis AP-3.10Q (EB95) RPPM110A

Description: This analysis will interactively integrate and reanalyze the FEPs and failure modes that will be investigated within each of the principal EBS models: the Water Distribution and Removal Model, Physical and Chemical Environment Model and EBS Radionuclide Transport Model. For the important FEPs and failure modes, initiating conditions/events will be identified. The analysis will also address coupling among failure modes of the multiple-barrier system, sensitivities to initiating events and the potential effects of coupled degradation modes.

Input Data: EBS AP-3.10Q analysis and model reports for Water Distribution and Removal Model, Physical and Chemical Environment Model, and EBS Radionuclide Migration ModeEBS Process Models

Feeds To: EBS FEPs/ Process ModelsDegradation Modes Abstraction

Responsible Organization: EBSO

Due Date: 2 Dec 99

22) EBS FEPS/Degradation Modes Abstraction AP-3.10Q (EB125) RPPM045A

Description: The abstraction will be based on the result of the corresponding process model analysis, EB95, and will be implemented directly within the TSPA-SR/LA calculations using the RIP model.

Input Data: EBS AP-3.10Q Analysis and model reports for Water Distribution and Removal Model, Physical and Chemical Environment Model, EBS Radionuclide Migration Model, and EBS FEPs/Degradation Models Analysis

Feeds To: TSPA

Responsible Organization: PAO

Due Date: 29 Dec 99

23) PCE Model Valid Expert/Analysis (EB015)

Description: Not available at this time.

Input Data:

Feeds To:

Responsible Organization: EBSO

Due Date: 14 Sep 99

ANALYSIS AND MODEL REPORTS SUPPORTING THE BIOSPHERE PMR		
	Title	Resp. Org.
1	GENII-S Non-Disruptive Event BDCF Analysis	SO
2	Dose Conversion Factor Analysis	SO
3	Transfer Coefficients Analysis	SO
4	Environmental Transport Parameters Analysis	SO
5	Ingestion Exposure Analysis	SO
6	Inhalation Exposure Analysis	SO
7	External Exposure Analysis	SO
8	Critical Group Analysis	SO
9	Soil Buildup Factor Analysis	PAO
10	Disruptive Event Biosphere Dose Conversion Factor Analysis	SO
11	Non-Disruptive Event Sensitivity Analysis	SO
12	Disrupted Performance Sensitivity Analysis	PAO
13	Annual Groundwater Usage Analysis	PAO
14	Biosphere Dose Conversion Factor Distribution Analysis	PAO
15	Biosphere Dose Conversion Factor/Soils Buildup of Radionuclides Abstraction	PAO
16	Radionuclide Removal from Soils Analysis	PAO
17	Features, Events, and Processes (FEPs) Analysis	SO
18	Distribution Fit BDCF	

Analysis and Model Reports Supporting the Biosphere PRM

1) GENII-S Non-Disruptive Event BDCF Analysis (SSPMR260)

Description: Analysis develops the probability distributions of biosphere dose conversion factors for the undisturbed performance scenario in which radionuclides are released to the environment via a contaminated groundwater from a well and the use of this water for domestic and agricultural purposes. Radionuclide buildup in soil as a result of prior irrigation practices will be considered

Input Data: Data from the following analyses: Dose Conversion Factor Analysis, Transfer Coefficient Analysis, Environmental Transport Parameter Analysis, Ingestion Exposure Analysis, Inhalation Exposure Analysis, External Exposure Analysis, and Critical Group Analysis

Feeds to: Distribution Fit: Non-Disruptive Event BDCF Analysis, Non-disruptive event sensitivity analysis

Responsible Organization: SO

Due Date: 16 Aug 99

2) Dose Conversion Factor Analysis SSPMR100

Description: Selection and justification for the use of specific set of dose conversion factors for radionuclides of interest.

Input Data: Identification of radionuclides of interest by PAO and data from published scientific literature.

Feeds to: Disruptive Events (Tectonic Hazards) and Base Case Biosphere Dose Conversion Factor Analyses

Responsible Organization: SO

Due Date: 2 Jun 99

3) Transfer Coefficients Analysis SSPMR120

Description: Development of food transfer coefficients used to quantify transfer of radionuclides from soil to food products (plants and animals). This assessment is part of the BDCFs calculation. Identification, documentation, selection and justification for the use of those factors in the calculation of the BDCFs will be included.

Input Data: Identification of radionuclides of interest by PAO and data from published scientific literature.

Feeds to: Disruptive Events (Tectonic Hazards) and Base Case Biosphere Dose Conversion Factor Analyses

Responsible Organization: SO

Due Date: 2 Jun 99

4) Environmental Transport Parameters Analysis SSPMR140

Description: Development of factors and parameters used in the assessment of environmental transport of radionuclides, which is an element in the BDCFs calculation. Identification, documentation, selection and justification for the use of those factors in the calculation of the BDCFs will be included.

Input Data: Identification of radionuclides of interest by PAO and data from published scientific literature.

Feeds to: Disruptive Events (Tectonic Hazards) and Base Case Biosphere Dose Conversion Factor Analyses

Responsible Organization: SO

Due Date: 2 Jun 99

5) Ingestion Exposure Analysis SSPMR160

Description: Development of ingestion exposure parameters used to support the calculation of BDCFs for both undisrupted performance and disrupted performance. Important ingestion exposure pathways will be identified. Identification, documentation, selection and justification for the use of ingestion exposure parameters in the calculation of the BDCFs will be included.

Input Data: Identification of radionuclides of interest by PAO, data from food consumption survey, and data from published scientific literature.

Feeds to: Disruptive Events (Tectonic Hazards) and Base Case Biosphere Dose Conversion Factor Analyses

Responsible Organization: SO

Due Date: 8 Jun 99

6) Inhalation Exposure Analysis SSPMR180

Description: Development of inhalation exposure parameters used to support the calculation of BDCFs for both undisrupted performance and disruptive events. Important inhalation exposure pathways will be identified. Identification, documentation, selection and justification for the use of inhalation exposure parameters in the calculation of the BDCFs will be included.

Input Data: Identification of radionuclides of interest by PAO and data from published scientific literature.

Feeds to: Disruptive Events (Tectonic Hazards) and Base Case Biosphere Dose Conversion Factor Analyses

Responsible Organization: SO

Due Date: 8 Jun 99

7) External Exposure Analysis SSPMR200

Description: Development of external exposure parameters used to support the calculation of BDCFs for both undisrupted performance and disruptive events. Important external exposure pathways will be identified. Identification, documentation, selection and justification for the use of external exposure parameters in the calculation of the BDCFs will be included.

Input Data: Identification of radionuclides of interest by PAO and data from published scientific literature.

Feeds to: Disruptive Events (Tectonic Hazards) and Base Case Biosphere Dose Conversion Factor Analyses

Responsible Organization: SO

Due Date: 2 Jun 99

8) Critical Group Analysis SSPMR240

Description: Identification of the critical group, consistent with the intent and process of 10 CFR 63, in terms of consumption rates of water and locally produced food.

Input Data: Food consumption survey data, previously completed, and data from published scientific literature.

Feeds to: Disruptive Events (Tectonic Hazards) and Base Case Biosphere Dose Conversion Factor Analyses

Responsible Organization: SO

Due Date: 8 Jun 99

9) Soil Buildup Factor Analysis SSPMR220

Description: Development of a model of radionuclide content in the soil as a function of both inputs and removal mechanisms. This model is intended to be used in assessment of the uncertainty in the BDCFs generated by GENII-S and to estimate radionuclide removal by erosion.

Input Data: Identification of radionuclides of interest by PAO and data from published scientific literature.

Feeds to: Biosphere Dose Conversion Factor/Soils Buildup of Radionuclide Abstraction

Responsible Organization: PAO

Due Date: 19 Jul 99

10) Disruptive Event Biosphere Dose Conversion Factor Analysis SSPMR340

Description: Analysis develops the probability distribution of BDCF for disruptive events including releases of radionuclides to the environment from a volcanic eruption.

Input Data: Dose Conversion Factor Analysis, Transfer Coefficient Analysis, Environmental Transport Parameter Analysis, Ingestion Exposure Analysis, Inhalation Exposure Analysis, External Exposure Analysis, and Critical Group Analysis

Feeds to: Disruptive Events Sensitivity Analysis

Responsible Organization: SO

Due Date: 18 Aug 99

11) Non-Disruptive Event Sensitivity Analysis SSPMR300

Description: Sensitivity analysis will be performed to identify pathways and parameters, which are the most significant from the radiation dose perspective.

Input Data: Data from the analysis of BDCF for undisturbed scenario plus the identification of key radionuclides of interest.

Feeds to: PMR

Responsible Organization: SO

Due Date: 31 Aug 99

12) Disrupted Performance Sensitivity Analysis SSPMR400

Description: Sensitivity analysis will be performed to identify parameters and pathways with the most significant impact on the BDCF for the key radionuclides of interest.

Input Data: Data from the analysis of BDCF for undisturbed scenario plus the identification of key radionuclides of interest.

Feeds to: PMR

Responsible Organization: PAO

Due Date: 1 Oct 99

13) Annual Groundwater Usage Analysis SSPMR320

Description: Analysis will develop a justifiable estimate of annual volumetric groundwater usage by the hypothetical community from which the critical group was constructed.

Input Data: Data on water usage will be obtained from the food consumption survey, the determination of the critical group characteristics, and agricultural data published by the state and/or county.

Feeds to: TSPA

Responsible Organization: PAO

Due Date: 17 Aug 99

14) Biosphere Dose Conversion Factor Distribution Analysis SSPMR280

Description: Abstraction will determine the statistical distribution of BDCF for the undisrupted performance case.

Input Data: BDCF distribution data from Non-Disruptive Event Analysis

Feeds to: BDCF/Soils Buildup of Radionuclide Abstraction

Responsible Organization: PAO

Due Date: 1 Oct 99

15) Biosphere Dose Conversion Factor/Soils Buildup of Radionuclides Abstraction SSPMR380

Description: Abstraction will develop a functional relationship between the value sof the BDCF for radionuclides of interest and the duration of prior irrigation times.

Input Data: Distribution fit data for BDCF for key radionuclides as a function of previous irrigation times.

Feeds to: TSPA, PMR

Responsible Organization: PAO

Due Date: 18 Oct 99

16) Radionuclide Removal from Soils Analysis SSPMR360

Description: Analysis will develop a model describing the process of depletion of radionuclides from soil/ash following a volcanic eruption.

Input Data: Identification of key radionuclides of interest for disruptive events and relevant data from the scientific literature.

Feeds to: TSPA, PMR

Responsible Organization: PAO

Due Date: 2 Sep 99

17) Features, Events, and Processes (FEPs) Analysis SSPMR420

Description: Analysis will identify incorporation of relevant FEPs in Biosphere

Input Data: FEPs Team

Feeds to: PMR, TSPA

Responsible Organization: SO

Due Date: 15 Oct 99

18) Distribution Fit BDCF (P2000)

Description: Not available at this time.

Input Data:

Feeds To:

Responsible Organization: SO

Due Date: 1 Dec 99

			ANALYSIS AND MODEL REPORTS SUPPORTING TECTONIC HAZARDS PMR	
			Title	**Resp. Org**
			Volcanism	
		1	Framework for Igneous Activity at Yucca Mountain	NEPO
		2	Dike Propagation Near Drifts	PAO
		3	Characterize Eruptive Processes	NEPO
		4	Waste Package Behavior – Magma	WPO
		5	Waste Form Behavior – Magma	WPO
		6	Deposition of Ash/Dose Pathways	PAO
		7	Repository and Drift Design	EBSO
		8	Number of Packages Hit	PAO
		9	Waste Entrainment	NEPO
		10	Consequence Analysis for Direct Release	PAO
			Seismicity	
		11	Framework for Seismicity and Structural Deformation	NEPO
		12	Characteristics of Faults	NEPO
		13	Fault Displacement Effects on EBS	NEPO
		14	Fault Displacement Effects on Hydrology	PAO
		15	Tunnel Stability (Rockfall Damage) Model	NEPO
		16	Enhanced Degradation of Waste Form	NEPO
		17	RIP Source/Seismic Rockfall	PAO
		18	Consequence Analysis Results	PAO
		19	Evaluate/Screen Tectonics Features, Events, and Processes	PAO
		20	Disruptive Events Abstraction	PAO
		21	Direct Surface Release from Eruption	PAO
		22	Waste Redistribution and BDCFs	S&H

Analysis and Modeling Reports Supporting the Tectonic Hazards PMR

VOLCANISM

1) Framework for Igneous Activity at Yucca Mountain (V1110) SLA8010, SLA8012, SLA8014, SLA8016, SLA8016M4

Description: Describe the conceptual model of volcanism at Yucca Mountain drawing from the interpretations considered in the probabilistic volcanic hazard analysis (PVHA). Summarize the hazard determined from the PVHA.

Develop a probability distribution function (PDF) for the length and orientations of dike intersections within the repository footprint. Also develop a PDF for the number of eruptive vents within the repository footprint, conditional on dike intersection. These distributions are to be based on information in the PVHA. Document the conceptual model that supports construction of the PDFs.

Input Data: V1230 Number of Packages Hit; PVHA report and results [Results need to be submitted to the TDMS)

Feeds to: Preparation of Chapter 3 of the report, *Consequences of Tectonic Events for Performance Assessment*

Responsible Organization: NEPO

Due Date: 30-Sep-99

2) Dike Propagation Near Drifts (V1140) SLA8030, SLA8032, SLA8034, SLA8036, SLA8036M4

Description: Describe the likely paths taken by ascending magma as it transitions from country rock to the stress-altered rock in the vicinity of the drifts.

Input Data:

Feeds to: V1230 Number of Packages Hit; Preparation of Chapter 3 of the report, *Consequences of Tectonic Events for Performance Assessment*

Responsible Organization: PAO

Due Date: 30-Oct-99

3) Characterize Eruptive Processes (V1150) SLA8040, SLA8042, SLA8044, SLA8046, SLA8046M4

Description: Describe the geometry(s), size(s), spatial distribution, duration, number of events and other key parameters associated with the development of eruptive conduits.

Characterize the expected fragmentation behavior from the intrusion fluid through changes upon eruption into and through the repository and discharge of the ash plume into the atmosphere.

Describe the direct surface release of radioactive material that is likely to result from a volcanic eruption through the repository. Describe entrainment in and dispersal of radioactivity in ash plumes. Describe the amount of radioactive material likely to be released, waste particle sizes and other parameters needed for input into ASHPLUME modeling.

Produce PDFs describing the likely widths, lengths, temperatures, and chemical characteristics of dikes intruding the repository footprint. Develop PDFs for the column height, volume, duration of various phases, exit velocity, ash particle size and shape, of volcanic eruptions that are postulated to intersect the repository.

Use the ASHPLUME code to calculate the physical characteristics of the ash blanket that is produced by an eruption through the repository. Describe likely spatial and temporal (if appropriate) variations in the physical characteristics. Include descriptions of the thickness(es), particle size distribution, and any other parameters needed to support estimates of dose at the receptor site(s). Use a range of inputs to get a distribution. Describe the chemical and mineralogic forms of the ash and waste that are deposited.

Input Data:

Feeds to: V1410 Consequence Analysis for Direct Release; Preparation of Chapter 3 of the report, *Consequences of Tectonic Events for Performance Assessment*

Responsible Organization: NEPO

Due Date: 15-Oct-99

4) Waste Package Behavior – Magma (V1160) SLA8050, SLA8052, SLA8054, SLA8056, SLA8056M4

Description: Describe the method of waste package failure, as a function of time, for packages in direct contact with magma flow during igneous events. Describe the waste package temperature evolution, the physical evolution of magma around waste packages, geochemical evolution of the magma, and the effects of these changes on the failure of contacted waste package(s). Describe the process for magma breach of the waste package. Calculate time histories of waste-package failure modes, including internal overpressure, plastic deformation, and corrosion resulting from direct contact of erupting magma with the containers. Develop PDFs for failure over the period of violent eruptions.

Input Data:

Feeds to: V1410 Consequence Analysis for Direct Release; Preparation of Chapter 3 of the report, *Consequences of Tectonic Events for Performance Assessment*

Responsible Organization: WPO

Due Date: 15-Oct-99

5) Waste Form Behavior – Magma (V1170) SLA8060, SLA8062, SLA8064, SLA8066, SLA8066M4

Description: Describe the behavior of the waste form(s) in direct contact with magma. Describe changes in physical and chemical characteristics of the waste form(s) that result from direct contact with magma. Produce PDFs describing range of particle sizes resulting from contact of waste with erupting magma.

Input Data:

Feeds to: V1410 Consequence Analysis for Direct Release; Preparation of Chapter 3 of the report, *Consequences of Tectonic Events for Performance Assessment*

Responsible Organization: WPO

Due Date: 15-Oct-99

6) Deposition of Ash/Dose Pathways (V1190) SLA8080, SLA8082, SLA8084, SLA8086, SLA8086M4

Description: Describe the redistribution of ash and radioactive waste particles from an ash blanket to a receptor population. Identify the various dose pathways to receptors at the dose site assuming the receptor population is not present during the ashfall event but returns soon afterward. Describe the conceptual framework that incorporates (1) the roles of subsequent geologic processes in the redistribution of waste and (2) the effects of these processes on potential exposures at identified receptor sites. Describe the conceptual models for exposure pathways that are applicable to dose calculations at identified receptor sites. Calculate the redistribution of soil containing contaminated volcanic ash arising from wind and water processes. Provide biosphere dose conversion factors for radionuclides contained in ash plumes and/or lavas at identified receptor sites for given ash-blanket thicknesses, and after consideration of redistribution mechanisms.

Input Data:

Feeds to: V1410 Consequence Analysis for Direct Release; Preparation of Chapter 3 of the report, *Consequences of Tectonic Events for Performance Assessment*

Responsible Organization: PAO

Due Date: 15-Oct-99

7) Repository and Drift Design (Data Feed, not an analysis) (V1220) RPT1038

Description: Describe the basic repository layout and drift design, including drift size and spacing, ground support methods and materials, invert materials, waste package supports, and other design parameters, such as backfill, that could affect magmatic interactions.

Input Data: SR Design

Feeds to: V1230 Number of Packages Hit (Calculation); Preparation of Chapter 3 of the report, *Consequences of Tectonic Events for Performance Assessment*

Responsible Organization: EBSO

Due Date: 29-Jul-99

8) Number of Packages Hit (V1230) SLA8110, SLA8112, SLA8114, SLA8116, SLA8116M4

Description: Provide an estimate of the number of waste packages that would be contacted by a dike and/or a volcanic eruption. Document the basis for determining the number of waste packages contacted.

Input Data:

Feeds to: V1410 Consequence Analysis for Direct Release; Preparation of Chapter 3 of the report, *Consequences of Tectonic Events for Performance Assessment*

Responsible Organization: PAO

Due Date: 29-Oct-99

9) Waste Entrainment (V1310) SLA8140, SLA8142, SLA8144, SLA8146, SLA8146M4

Description: Produce PDFs describing the ranges of particle sizes relative to magma ascent velocities that could result in entrainment of waste released by breaching of waste packages by volcanic eruption through the repository. Describe the amount of radioactive material likely to be released, waste particle sizes and other parameters needed for input into ASHPLUME.

Input Data:

Feeds to: V1340 Ash Blanket Characteristics and Composition V1400 Results for Dike Intersection/Vent; V1410 Consequence Analysis for Direct Release; Preparation of Chapter 3 of the report, *Consequences of Tectonic Events for Performance Assessment*

Responsible Organization: NEPO

Due Date: 30-Sep-99

10) Consequence Analysis for Direct Release (V1410) SLA8230, SLA8232, SLA8324, SLA8236, SLA8236M4

Description: Describe the results of a volcanic eruption in the repository. Summarize the changes in mechanical, physical, and chemical properties of the natural and engineered barriers that would be expected. Summarize the characteristics of ash plume(s) and lava(s) that would be expected to result. Summarize the release of radioactive materials that would be expected and the spatial variability of radioactivity at identified receptor sites.

Input Data:

Feeds to: Preparation of Chapter 3 of the report, *Consequences of Tectonic Events for Performance Assessment*

Responsible Organization: PAO

Due Date: 24-Nov-99

SEISMICITY

11) Framework for Seismicity and Structural Deformation (Z1030) SLA8240, SLA8242, SLA8244, SLA8246, SLA8246M4

Description: Summarize information in the Probabilistic Seismic Hazard Analysis relevant to occurrences of structural deformation and seismicity events in the Yucca Mountain area. Deaggregate the hazard estimates presented in the PSHA and evaluate the sensitivity of near-surface ground motion and fault displacement hazards to the selection of a model. Identify the conceptual models and data required by PA for seismic disruptive events probability modeling. Describe the ground motion hazard curves developed for the Yucca Mountain site. Describe the median annual probability of exceedance and the 15^{th} and 85^{th} percentile values. Describe the peak ground velocity hazard curves. Justify and document the hazard curves for peak ground velocity based on the PSHA models. Document the transformations of the hazard curves necessary to present peak ground velocity values at repository depth.

Input Data: PSHA; PGV conversion from reference rock outcrop to repository depth.

Feeds to: Preparation of Chapter 2 of the report, *Consequences of Tectonic Events for Performance Assessment*

Responsible Organization: NEPO

Due Date: 24-Sep-99

12) Characteristics of Faults (Z1060)

Description: Describe the characteristics of known faults in the Yucca Mountain area based on the results of surface and underground mapping and information from drill holes. Include information about fault segment lengths, widths, attitudes (strikes and dips), slip directions, slip rates, cumulative displacement, and linkages between faults. Describe the potential of fault displacement to affect permeability within or immediately adjacent to the repository.

Input Data:

Feeds to: Preparation of Chapter 2 of the report, *Consequences of Tectonic Events for Performance Assessment*

Responsible Organization: NEPO

Due Date: 17-Sep-99

13) Fault Displacement Effects on EBS (Z1070) SLA8270, SLA8272, SLA8274, SLA8276, SLA8276M4

Description: Describe effects of fault displacement on components of the engineered barrier system such as effects on waste package supports, integrity of the inverts, and pillar stability.

Input Data:

Feeds to:

Responsible Organization: NEPO

Due Date: 15-Oct-99

14) Fault Displacement Effects on Hydrology (Z1080) SLA8280, SLA8282, SLA8284, SLA8286, SLA8286M4

Description: Describe the potential for postclosure faulting to affect the hydrologic properties of the site and the surrounding area such that the postclosure performance of the repository system could be affected. Discuss the potential for fault displacement to create perched water bodies, produce changes in the piezometric surface, or alter the hydrologic characteristics of the unsaturated zone or saturated zone.

Input Data:

Feeds to: Preparation of Chapter 3 of the report, *Consequences of Tectonic Events for Performance Assessment*

Responsible Organization: PAO

Due Date: 30-Sep-99

15) Tunnel Stability (Rockfall Damage) Model (Z1100)

Description: Develop a PDF that describes the postclosure static and dynamic rockfall hazard. Define a rockfall event for modeling purposes. Describe the single-block rockfall size and the distribution of masses for rocks dislodged as a result of ground motion as functions of time.

Input Data:

Feeds to: Preparation of Chapter 3 of the report, *Consequences of Tectonic Events for Performance Assessment*

Responsible Organization: NEPO

Due Date: 29-Oct-99

16) Enhanced Degradation of Waste Form (Z1120)

Description: Develop a PDF describing the probability of disruption of the cladding and any other degradational changes to the waste form that could result from fault displacement or ground shaking.

Input Data:

Feeds to: Z1130 RIP Source / Seismic Rockfall; Preparation of Chapter 3 of the report, *Consequences of Tectonic Events for Performance Assessment*

Responsible Organization: NEPO

Due Date: 29-Oct-99

17) RIP Source / Seismic Rockfall (Z1130)

Description: Integrate rockfall damage to waste packages with degradation resulting from corrosion. Incorporate this integrated waste-package failure into the base-case RIP calculations.

Input Data:

Feeds to: Z1160 Consequence Analysis Results
Preparation of Chapter 3 of the report, *Consequences of Tectonic Events for Performance Assessment*

Responsible Organization: PAO

Due Date: 10-Nov-99

18) Consequence Analysis Results (Z1160)

Description: Summarize the PA consequences of rockfall, fault displacement, and hydrologic changes that could result from seismic activity.

Input Data: Rockfall model

Feeds to: Preparation of Chapter 3 of the report, *Consequences of Tectonic Events for Performance Assessment*

Responsible Organization: PAO

Due Date: 18-Nov-99

19) Evaluate/Screen Tectonics Features, Events and Processes (ADD1)

Description: Evaluate the list of tectonic features, processes, and events (FEPs) and determine whether they should be screened in or out of the performance assessment analyses.

Input Data: FEPs list

Feeds to: Preparation of Chapter 2 of the report, *Consequences of Tectonic Events for Performance Assessment*

Responsible Organization: PAO

Due Date: 30 Sep 99

20) Disruptive Events Abstraction (ABS)

Description: Not available at this time.

Input Data:

Feeds to:

Responsible Organization: PAO

Due Date: 9 Dec 99

21) Direct Surface Release from Eruption (V1180)

Description: Not available at this time.

Input Data:

Feeds to:

Responsible Organization: PAO

Due Date: 29 Oct 99

22) Waste Redistribution and BDCFs (V1370)

Description: Not available at this time.

Input Data:

Feeds to:

Responsible Organization: S&H

Due Date: 29 Oct 99

PMR's/Key Documents Matrix

1) c) v)

Key Documents Supporting SR/LA

DOCUMENT	SITE RECOMMENDATION	LICENSE APPLICATION
	Volume-Chapter	Chapter
PMRs		
Integrated Site Model	1-1, 2-4	3, 12
UZ Flow and Transport	1-1, 1-4, 2-2, 2-4	3, 6, 8, 12
SZ Flow and Transport	1-1, 1-4, 2-2, 2-4	3, 8, 12
Near Field Environment	1-4, 2-2	3, 5, 6, 8, 12
WP Degradation	1-4, 2-2	5, 8, 12
WF Degradation	1-4, 2-2	5, 7, 8, 12
EBS Degradation/Flow/Transport	1-4, 2-2	5, 6, 8, 12
Biosphere	1-4, 2-2	8
Tectonic Hazards	1-4, 2-2, 2-4	3, 5, 6, 7, 8
Science Reports		
Site Description	1-1, 2-4	3
Natural Resources	1-4, 2-4	NA
Natural Analogs	1-1	8
System Description Documents		
Surface	1-2	2, 4, 9
Subsurface	1-2	2, 6
Waste Package	1-3	2, 5
TSPA		
TSPA-SR	1-1, 2-2	NA
TSPA-LA	NA	8

PMR Cost Table

1) c) vi)

PROCESS MODEL REPORT and AP-3.10Q R.O.M. COSTS
(k$)

CODE	TITLE	FY99	FY00	FY01	FY02	TOTAL
ISM	Integrated Site Model	659	400	400	0	1459
UZ	Unsaturated Zone Flow and Transport	686	5,088	4,639	0	10,413
SZ	Saturated Zone Flow and Transport	380	2,725	1,743	0	4,848
NF	Near Field Environment	763	2,552	1,600	0	4,915
WP	Waste Package Degradation	1,470	2,604	1,826	0	5,900
WF	Waste Form Degradation	1,421	2,362	1,661	0	5,444
EB	Engineered Barrier System Degradation and Flow/Transport	1,300	4,327	4,236	0	9,863
Bio	Biosphere	600	2,100	1,000	0	3,700
Tec	Tectonic Hazards	600	2,285	1,745	0	4,630
M&I	Management & Integration/Documentation Support Services	1,700	3,500	3,800	0	9,000
	Totals by FY	$9,579	$27,943	$22,650	$0	$60,172

Data Qualification Plan and Status

1) c) vii)

Data Qualification Plan and Status

The strategy for qualifying the technical data, models, and software needed for SR/LA is contained in the M&O's Data, Model and Code Qualification/Validation and Control Plan, developed in December 1998 (Reference 7).

As part of the resolution of CARs 98-002, 98-006, and 98-010, verification of the "Q" status of the Data Tracking Numbers (DTNs) and Codes used for the Viability Assessment (VA) that were likely to go forward to the SR/LA was initiated.

Of the data used in the VA, 372 DTNs were identified as likely to be used in the SR/LA. Of these 372 DTNs, 56 are in the process of being verified. One DTN has already been taken through the entire verification checklist process.

Of the codes used in the VA, 136 were identified as likely to be used in the SR/LA. Of these 136 codes, 28 are in the process of being verified. Eleven have already completed the verification process and have been placed under baseline control.

As described in the Narrative of this CR, the M&O has commissioned Tiger Teams to identify the complete listing of the data, models, and codes that need to be made traceable and defensible for SR/LA. A listing of the Tiger Teams organized to date is contained in the next section.

Tiger Team Goals

1) c) viii)

Tiger Teams and Their Goals

Tiger Team	Responsible Manager
1. UZ Site Scale Flow and Transport Model	Dwight Hoxie, USGS
2. UZ Drift Scale Ambient Seepage Model	Dwight Hoxie, USGS
3. UZ Mountain Scale and Drift Scale Thermohydrology Model	Dwight Hoxie, USGS
4. UZ Mountain Scale and Drift Scale Thermo-Hydrologic-Chemical Model	Dwight Hoxie, USGS
5. Net Infiltration/Surface Infiltration Model	Dwight Hoxie, USGS
6. Integrated Site Model	Stephen George, M&O
7. SZ Site Scale Flow and Transport Model	Dwight Hoxie, USGS
8. Multi-Scale Thermohydrology Abstraction Model	Dwight Hoxie, USGS
9. Near Field Chemical Water Composition Model	Dwight Hoxie, USGS
10. Near Field/Altered Zone Radionuclide Retardation/ Solubility Model	Dwight Hoxie, USGS
11. Coupled Thermal-Hydrological-Mechanical Model	Dwight Hoxie, USGS
12. Disruptive Events Abstraction Model	Jerry McNeish, M&O
13. Waste Form Abstraction Model	Rob Howard, M&O
14. EBS Transport Abstraction Model	Rob Howard, M&O
15. Waste Package Abstraction Model	Rob Howard, M&O
16. Geochemical Environment Abstraction Model	Rob Howard, M&O
17. Biosphere Abstraction Model	Cliff Ho, M&O
18. SZ Flow and Transport Abstraction Model	Cliff Ho, M&O
19. Thermal Hydrology Abstraction Model	Cliff Ho, M&O
20. Climate and Infiltration Abstraction Model	Cliff Ho, M&O
21. Seepage Abstraction Model	Cliff Ho, M&O
22. UZ Flow Abstraction Model	Cliff Ho, M&O
23. UZ Transport Abstraction Model	Cliff Ho, M&O
24. TSPA	Jerry McNeish, M&O
25. Waste Package Degradation Model	Dave Stahl, M&O
26. Waste Form Degradation Model	Dave Stahl, M&O
27. Biosphere Model	John Schmitt, M&O
28. Engineered Barrier Degradation and Transportation Model	Dwayne Chestnut, M&O
29. Water Distribution and Removal Model	Dwayne Chestnut, M&O
30. Physical/Chemical Conditions Model	Dwayne Chestnut, M&O
31. Radionuclide Migration Control Model	Dwayne Chestnut, M&O

Tiger Team Goals

Provide documentation for the following:

- the user-defined input parameters (parameter values) that are used to run the codes/software that will be used to support performance-assessment arguments in the Site Recommendation/License Application
- the actual value/distribution used for each parameter value used to produce results reported in the Site Recommendation/License Application and the rationale for their selection
- the source(s) for each parameter value and any intermediate calculations/data manipulations used to determine the parameter value from the source data on a layer-by-layer basis
- the trail from identified sources (e.g., Data Tracking Numbers (DTN)) to any field or laboratory determinations on which data/conclusions in the source were based, including all intermediate calculations or steps, supporting records, and qualification status.

The documentation must be of sufficient detail and clarity that a qualified independent party could trace the derivation of any parameter value back to the lowest-level source data and records. The independent party must be able to recreate the parameter value from the information presented or cited in the documentation without recourse to the original investigators or modelers.

The most recent revision of the manual, "Yucca Mountain Site Recommendation/License Application Total System Performance Assessment Controlled Database Development Plan (rev C) that active, potential, and future Tiger Team members were/are trained to is available upon request. An overview of how Tiger Teams work with the PVAR and data qualification efforts is included in "Data, Model and Code Qualification / Validation and Control Plan", December 1998, provided as Reference 7 of this Change Request.

Deliverable Deletion Rational Matrix

1) c) iv)

Disposition of Level 3 Deliverables Being Deleted or Altered Under This Change Request								
					Planned Deliverable Disposition Under This Change Request			
Deliverable Being Deleted or Altered	Abbreviated Deliverable Title	Current Deliverable Date	Responsible M&O Mgr	Responsible YMSCO Asst Mgr or Designee	New Location Where Data/Information will be Captured	New Completion Date	Estimated Cost Benefit ($k)	Date Discussed and Agreed Upon
NEPO								
SP32E1M3	Prow Pass Reactive Tracer Test Report	01-Apr-99	Hayes	Patterson	Submit existing data to TDMS and incorporate test results into the AP3.10Q's supporting the SZ PMR.	28-Apr-00	25	19-Apr-99
SP9904M3	Final LBT Report	12-Aug-99	Hayes	Patterson	Submit existing data to TDMS and incorporate test results into the AP3.10Q's supporting the NFE PMR.	03-Mar-00	25	19-Apr-99
SP399CM3 PEMP 13-1	NF/AZ Environment Report Volume 1, Rev 2	30-Aug-99	Hayes	Patterson	Submit existing data to TDMS and incorporate test results into the AP3.10Q's supporting the NFE PMR.	03-Mar-00	25	19-Apr-99
SP32K5M3 PEMP 13-1	Integrated Site Model 3.0 Report	31-Mar-99	Hayes	Patterson	Submit existing data to TDMS and incorporate test results into the AP3.10Q's supporting the ISM PMR.	29-Oct-99	25	19-Apr-99
SPG42GM3	Geo/Geotech Data fm X-Block Drift Project	31-Mar-99	Hayes	Patterson	Submit existing data to TDMS and incorporate test results directly into ISM PMR. (L3)	16-Aug-99	0	19-Apr-99
SP32P4M3	ISM3.1 Addendum to ISM3.0 report	28-May-99	Hayes	Patterson	Submit existing data to TDMS, incorporate min/pet data from WT-24 and SD-6 into the AP3.10Q's supporting the ISM PMR.	29-Oct-99	25	19-Apr-99
SPG640M3	Correlation of Litho & Geophysical Data Report	30-Sep-99	Hayes	Patterson	Submit existing data to TDMS and incorporate test results into the AP3.10Q's supporting the ISM PMR.	unchanged	25	19-Apr-99
SP3120M3	Single Heater Test Final Report (L3)	14-Apr-99	Hayes	Patterson	Submit existing data to TDMS and incorporate test results directly into NFE PMR. (L3)	28-May-99	0	19-Apr-99
SPQ224M3	R1 Seismic Design Basis Inputs Report	31-Aug-99	Hayes	Patterson	Incorporate data and results with FY98 report SP24IM3, combine SP24IM3 and SPQ224M3 into AP3.10Q's.	31-Aug-99	25	19-Apr-99
SP3880M3	Drift Scale Test Progress Report #2	29-Sep-99	Hayes	Patterson	Submit existing data to TDMS and incorporate test results into the AP3.10Q's supporting the NFE PMR.	03-Mar-00	25	19-Apr-99

Disposition of Level 3 Deliverables Being Deleted or Altered Under This Change Request								
					Planned Deliverable Disposition Under This Change Request			
Deliverable Being Deleted or Altered	Abbreviated Deliverable Title	Current Deliverable Date	Responsible M&O Mgr	Responsible YMSCO Asst Mgr or Designee	New Location Where Data/Information will be Captured	New Completion Date	Estimated Cost Benefit ($k)	Date Discussed and Agreed Upon
SP23GM3	Natural Resources Final Report	02-Jun-97	Hayes	Patterson	Submit existing data to TDMS and incorporate test results into the AP3.10Q's supporting several PMRs.	N/A	25	19-Apr-99
SP24IM3	Seismic Design Inputs for a Geol. Repos. At YM	25-Feb-98	Hayes	Patterson	Incorporate changes requested by DOE and M&O Design. Combine results with FY99 report SPQ224M3 and into AP3.10Q's.	31-Aug-99	25	19-Apr-99
SPG28LM3	Deterministic Evals for Type 1 faults at YM	19-Dec-97	Hayes	Patterson	Per DOE's review, additional work needs to be done to resolve difference of opinion on how velocity calibrations from depth to surface are to be determined. Submit existing data to TDMS, review and complete report.	30-Sep-99	0	19-Apr-99
SP3CKJM3	Update UZ Hydrologic Flow Model	30-Sep-98	Hayes	Patterson	Submit existing data to TDMS and incorporate test results into the AP3.10Q's supporting the UZ F&T PMR.	17-Mar-00	25	19-Apr-99
SP33PBM3	Fracture Flow & Seepage Testing in ESF	31-Mar-99	Hayes	Patterson	Submit existing data to TDMS and incorporate test results into the AP3.10Q's supporting the UZ F&T PMR.	17-Mar-00	25	19-Apr-99
SP39B2M3	Predictive Report for USW SD-6 Borehole	29-Aug-97	Hayes	Patterson	Submit existing data to TDMS and incorporate test results into the AP3.10Q's supporting the ISM PMR.	N/A	25	19-Apr-99
SP39B3M3	Analysis of Predictions for USW WT-24 Borehole	14-Aug-98	Hayes	Patterson	Submit existing data to TDMS and incorporate test results into the AP3.10Q's supporting the ISM PMR.	N/A	25	19-Apr-99
Performance Assessment								
SL9050M3	Complete Info Feeds for Science and Design to TSPA	30-Sep-99	Andrews	Tynan	N/A; Information feeds will be less			
SL921M3	TSPA-SR Rev. 00	14-Jul-00	Andrews	Tynan	N/A: Less content than originally planned			

Disposition of Level 3 Deliverables Being Deleted or Altered Under This Change Request

					Planned Deliverable Disposition Under This Change Request			
Deliverable Being Deleted or Altered	Abbreviated Deliverable Title	Current Deliverable Date	Responsible M&O Mgr	Responsible YMSCO Asst Mgr or Designee	New Location Where Data/Information will be Captured	New Completion Date	Estimated Cost Benefit ($k)	Date Discussed and Agreed Upon
SL924M3	TSPA-SR Rev. 01	29-Feb-01	Andrews	Tynan	N/A: More bounding analyses will be used			
SL916M3	PA Input to DEIS	26-Feb-99	Andrews	Tynan	Delay completion of deliverable to accommodate DOE/MTS comments on SL916M4	31-Mar-99		
Waste Package								
WP110M3	Submit WFCR Update to DOE for SR	31-Mar-00	Benton	Spence	Characteristics Report being deleted - replaced by Process Model Report			
WP110M3	Submit WFMR to DOE/PA for SR		Benton	Spence	Add Waste Form Model Report	31-Mar-00	0	
WP20CM3	Submit EMCR Update to DOE for SR	24-Apr-00	Benton	Spence	Characteristics Report being deleted - replaced by Process Model Report			
WP20CM3	Submit EBMMR to DOE/PA for SR		Benton	Spence	Add Engr Barrier Material Model Report	24-Apr-00	0	
WP275M3	Summary Report of Degraded WP Crit Evals	30-Sep-99	Benton	Russell	Delete deliverable; information will be contained n other WPO deliverables and products			
Engineered Barrier System								
RPA256M3	Hydraulics and Water Flow in the Drifts	30-Sep-99	Bhattacharyya	Gonzalez	Information will be incorporated into analyses supporting the EBS Transport PMR. Work has been reformatted to comply with new scope leading directly to the development of the PMR. Information that would be contained in this deliverable does not directly support SR or LA, but the PMR that supports PA and the development of the SR and LA.	30-Sep-99	73	18-Mar-99

Disposition of Level 3 Deliverables Being Deleted or Altered Under This Change Request

					Planned Deliverable Disposition Under This Change Request			
Deliverable Being Deleted or Altered	Abbreviated Deliverable Title	Current Deliverable Date	Responsible M&O Mgr	Responsible YMSCO Asst Mgr or Designee	New Location Where Data/Information will be Captured	New Completion Date	Estimated Cost Benefit ($k)	Date Discussed and Agreed Upon
RPA258M3	EBS Natural Analogs	30-Sep-99	Bhattacharyya	Gonzalez	Defer until FY00 due to prioritization of FY99 work given budget reductions. Work was prioritized according to importance and scheduling, and it was determined that this deliverable would have the least impact on overall EBS work load if it was deferred. Deliverable (and supporting activity) will be retitled as Engineered Analogs to reflect that the work deals with engineered items rather than natural systems.	TBD: April/May 2000	0	18-Mar-99
Regulatory and Licensing								
SL06X7M3	Submit Repository Safety Strategy Rev 3	28-May-99	Richardson	Van Luik	Delivery date extended to accommodate resources reallocation to PVAR effort.	28-Jul-99	0	05-May-99
SLWD02M3	M&O Provide WDLA QAP-6.2 Draft to DOE	30-Jul-99	Richardson	Gil	Criteria change for the WDLA will delete Chapters 3 & 8 per DOE Guidance Letter.	30-Jul-99	200	12-Feb-99

Disposition of FY97, FY98, and FY99 Level 3 Deliverables Being Deleted or Altered Under This Change Request									
Deliverable	Disposition	Abbreviated Deliverable Title	Current Deliverable Date	Responsible M&O Mgr	Responsible YMSCO Asst Mgr or Designee	New Location Where Data/Information will be Captured	Completion Date for New Action	Estimated Cost Benefit ($k)	Date Discussed and Agreed Upon
NEPO									
SP32E1M3	delete	Prow Pass Reactive Tracer Test Report	1-Apr-99	Hayes	Patterson	Submit existing data to TDMS and incorporate test results into the AP3.10Q's supporting the SZ PMR.	28-Apr-00	25	19-Apr-99
SP9904M3	delete	Final LBT Report	12-Aug-99	Hayes	Patterson	Submit existing data to TDMS and incorporate test results into the AP3.10Q's supporting the NFE PMR.	3-Mar-00	25	19-Apr-99
SP399CM3 PEMP 13-1	delete	NF/AZ Environment Report Volume 1, Rev 2	30-Aug-99	Hayes	Patterson	Submit existing data to TDMS and incorporate test results into the AP3.10Q's supporting the NFE PMR.	3-Mar-00	25	19-Apr-99
SPG42GM3	adjust date	Geo/Geotech Data fm X-Block Drift Project	31-Mar-99	Hayes	Patterson	Submit existing data to TDMS, incorporate test results into the ISM PMR, and complete report	16-Aug-99	0	19-Apr-99
SP32P4M3	delete	ISM3.1 Addendum to ISM3.0 report	28-May-99	Hayes	Patterson	Submit existing data to TDMS, incorporate min/pet data from WT-24 and SD-6 into the AP3.10Q's supporting the ISM PMR.	29-Oct-99	25	19-Apr-99
SPG640M3	delete	Correlation of Litho & Geophysical Data Report	30-Sep-99	Hayes	Patterson	Submit existing data to TDMS and incorporate test results into the AP3.10Q's supporting the ISM PMR.	30-Sep-99	25	19-Apr-99
SP3120M3	adjust date	Single Heater Test Final Report (L3)	14-Apr-99	Hayes	Patterson	Submit existing data to TDMS, incorporate test results into the NFE PMR and complete report	28-May-99	0	19-Apr-99
SPQ224M3	delete	R1 Seismic Design Basis Inputs Report	31-Aug-99	Hayes	Patterson	Incorporate data and results with FY98 report SP24IM3, combine SP24IM3 and SPQ224M3 into AP3.10Q's.	31-Aug-99	25	19-Apr-99
SP3880M3	delete	Drift Scale Test Progress Report #2	29-Sep-99	Hayes	Patterson	Submit existing data to TDMS and incorporate test results into the AP3.10Q's supporting the NFE PMR.	3-Mar-00	25	19-Apr-99
SP23GM3	delete	Natural Resources Final Report	2-Jun-97	Hayes	Patterson	Submit existing data to TDMS and incorporate test results into the AP3.10Q's supporting several PMRs.	various	25	19-Apr-99
SP24IM3	delete	Seismic Design Inputs for a Geol. Repos. At YM	25-Feb-98	Hayes	Patterson	Incorporate changes requested by DOE and M&O Design. Combine results with FY99 report SPQ224M3 and into AP3.10Q's.	31-Aug-99	25	19-Apr-99

Disposition of FY97, FY98, and FY99 Level 3 Deliverables Being Deleted or Altered Under This Change Request									
Deliverable	Disposition	Abbreviated Deliverable Title	Current Deliverable Date	Responsible M&O Mgr	Responsible YMSCO Asst Mgr or Designee	New Location Where Data/Information will be Captured	Completion Date for New Action	Estimated Cost Benefit ($k)	Date Discussed and Agreed Upon
SPG28LM3	adjust date	Deterministic Evals for Type 1 faults at YM	19-Dec-97	Hayes	Patterson	Per DOE's review, additional work needs to be done to resolve difference of opinion on how velocity calibrations from depth to surface are to be determined. Submit existing data to TDMS, review and complete report.	30-Sep-99	0	19-Apr-99
SP39B2M3	delete	Predictive Report for USW SD-6 Borehole	29-Aug-97	Hayes	Patterson	Submit existing data to TDMS and incorporate test results into the AP3.10Q's supporting the ISM PMR.	29-Oct-99	25	19-Apr-99
SP39B3M3	delete	Analysis of Predictions for USW WT-24 Borehole	14-Aug-98	Hayes	Patterson	Submit existing data to TDMS and incorporate test results into the AP3.10Q's supporting the ISM PMR.	29-Oct-99	25	19-Apr-99
Performance Assessment									
SL9050M3	adjust scope	Complete Info Feeds for Science and Design to TSPA	30-Sep-99	Andrews	Tynan	N/A; Information feeds will be less			
SL916M3	adjust date	PA Input to DEIS	26-Feb-99	Andrews	Tynan	Delay completion of deliverable to accommodate DOE/MTS comments on SL916M4	31-Mar-99		
Waste Package									
WP275M3	delete	Summary Rpt of Degraded WP Crit Evals	30-Sep-99	Benton	Russell	Delete deliverable; Information will be contained in other WPO deliverables and products		15	
Engineered Barrier System									
RPA256M3	delete	Hydraulics and Water Flow in the Drifts	30-Sep-99	Bhattacharyya	Gonzalez	Information will be incorporated into analyses supporting the EBS Transport PMR. Work has been reformatted to comply with new scope leading directly to the development of the PMR. Information that would be contained in this deliverable does not directly support SR or LA.	30-Sep-99	73	18-Mar-99

Disposition of FY97, FY98, and FY99 Level 3 Deliverables Being Deleted or Altered Under This Change Request									
Deliverable	Disposition	Abbreviated Deliverable Title	Current Deliverable Date	Responsible M&O Mgr	Responsible YMSCO Asst Mgr or Designee	New Location Where Data/Information will be Captured	Completion Date for New Action	Estimated Cost Benefit ($k)	Date Discussed and Agreed Upon
RPA258M3	adjust date	EBS Natural Analogs	30-Sep-99	Bhattacharyya	Gonzalez	Defer until FY00 due to prioritization of FY99 work given budget reductions. Work was prioritized according to importance and scheduling, and it was determined that this deliverable would have the least impact on overall EBS work load if it was deferred. Deliverable (and supporting activity) will be retitled as Engineered Analogs to reflect that the work deals with engineered items rather than natural systems.	TBD: April/May 2000	0	18-Mar-99
Regulatory and Licensing									
SL06X7M3	adjust date	Submit Repository Safety Strategy Rev 3	28-May-99	Richardson	Van Luik	Delivery date extended to accommodate resource reallocation to PVAR effort.	28-Jul-99	0	5-May-99
SLWD02M3	adjust scope	M&O Provide WDLA QAP-6.2 Draft to DOE	30-Jul-99	Richardson	Gil	Criteria change for the WDLA will delete Chapters 3 & 8 per DOE Guidance Letter.	30-Jul-99	200	12-Feb-99