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Evaluation of Features, Events, and Processes (FEP) for the Biosphere Model

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Revision History

12. Revision/ICN No.	13. Description of Revision/Change
Rev 00	Initial issue
Rev 01	Revised to include consideration of the proposed U.S. Nuclear Regulatory Commission Regulations (Federal Register for February 22, 1999, 64 FR 8640)
Rev 02	Revised to remove consideration of the proposed U.S. Nuclear Regulatory Commission regulations (Federal Register for February 22, 1999, 64 FR 8640) and Dyer (1999) and limit consideration of FEP applicability to

Addendum 1

final U.S. Nuclear Regulatory Commission regulations (Federal Register for November 2, 2001, 66 FR 55792) and to incorporate selected NRC /DOE agreement items

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ACRONYMS AND ABBREVIATIONS

A.P.	After Present
BDCF	biosphere dose conversion factor
DOE	U.S. Department of Energy
FEPs	features, events, and processes
NRC	U.S. Nuclear Regulatory Commission
RMEI	reasonably maximally exposed individual
SAR	Scientific Analysis Report
YMP	Yucca Mountain Project

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1. PURPOSE

The purpose of this revision of *Evaluation of the Applicability of Biosphere-Related Features, Events, and Processes (FEPs)* (BSC 2001) is to document the screening analysis of biosphere-related primary FEPs, as identified in *The Development of Information Catalogued in REV00 of the YMP FEP Database* (Freeze et al. 2001), in accordance with the requirements of the final U.S. Nuclear Regulatory Commission (NRC) regulations at 10 CFR Part 63. This database is referred to as the Yucca Mountain Project (YMP) FEP Database throughout this document. Those biosphere-related primary FEPs that are screened as applicable will be used to develop the conceptual model portion of the biosphere model, which will in turn be used to develop the mathematical model portion of the biosphere model. As part of this revision, any reference to the screening guidance or criteria provided either by Dyer (1999) or by the proposed NRC regulations at 64 FR 8640 has been removed. The title of this revision has been changed to more accurately reflect the purpose of the analyses.

In addition, this revision will address Item Numbers 19, 20, 21, 25, and 26 from Attachment 2 of “U.S. Nuclear Regulatory Commission/U.S. Department of Energy Technical Exchange and Management Meeting on Total System Performance Assessment and Integration (August 6 through 10, 2001)” (Reamer 2001). This Scientific Analysis Report (SAR) does not support the current revision to the YMP FEP Database (Freeze et al. 2001).

Subsequent to the release of the YMP FEP Database (Freeze et al. 2001), a series of reviews was conducted on both the FEP processes used to support Total System Performance Assessment for Site Recommendation and to develop the YMP FEP Database. In response to observations and comments from these reviews, particularly the NRC/DOE TSPA Technical Exchange in August 2001 (Reamer 2001), several Key Technical Issue (KTI) Agreements were developed. *The Enhanced Plan for Features, Events and Processes (FEPs) at Yucca Mountain* (BSC 2002a), herein referred to as the Enhanced FEP Plan, was developed to directly address KTI Agreement TSPA 2.05, and to generally address other KTI Agreements and issues (BSC 2002a, pp. 16 to 18). The Enhanced FEP Plan addresses the regulatory requirements of 10 CFR Part 63, identifies and implements specific enhancements, and supports the License Application (BSC 2002a, p. 2). This SAR is not intended to implement any of the enhancements identified in the Enhanced FEP Plan, although it does consider the intent of the Enhanced FEP Plan to simplify the screening analysis.

This SAR is one of nine technical reports containing the documentation for the biosphere model being developed, its input parameters, and the application of the model to develop biosphere dose conversion factors (BDCFs). Figure 1 shows the anticipated interrelationship between these nine technical reports and the Environmental Radiation Model for Yucca Mountain, Nevada (ERMYN), commonly referred to as the biosphere model. The biosphere model belongs to the series of process models supporting the Total System Performance Assessment for the License Application. Specifically, the biosphere model provides the performance assessment with the capability to perform dose assessment.

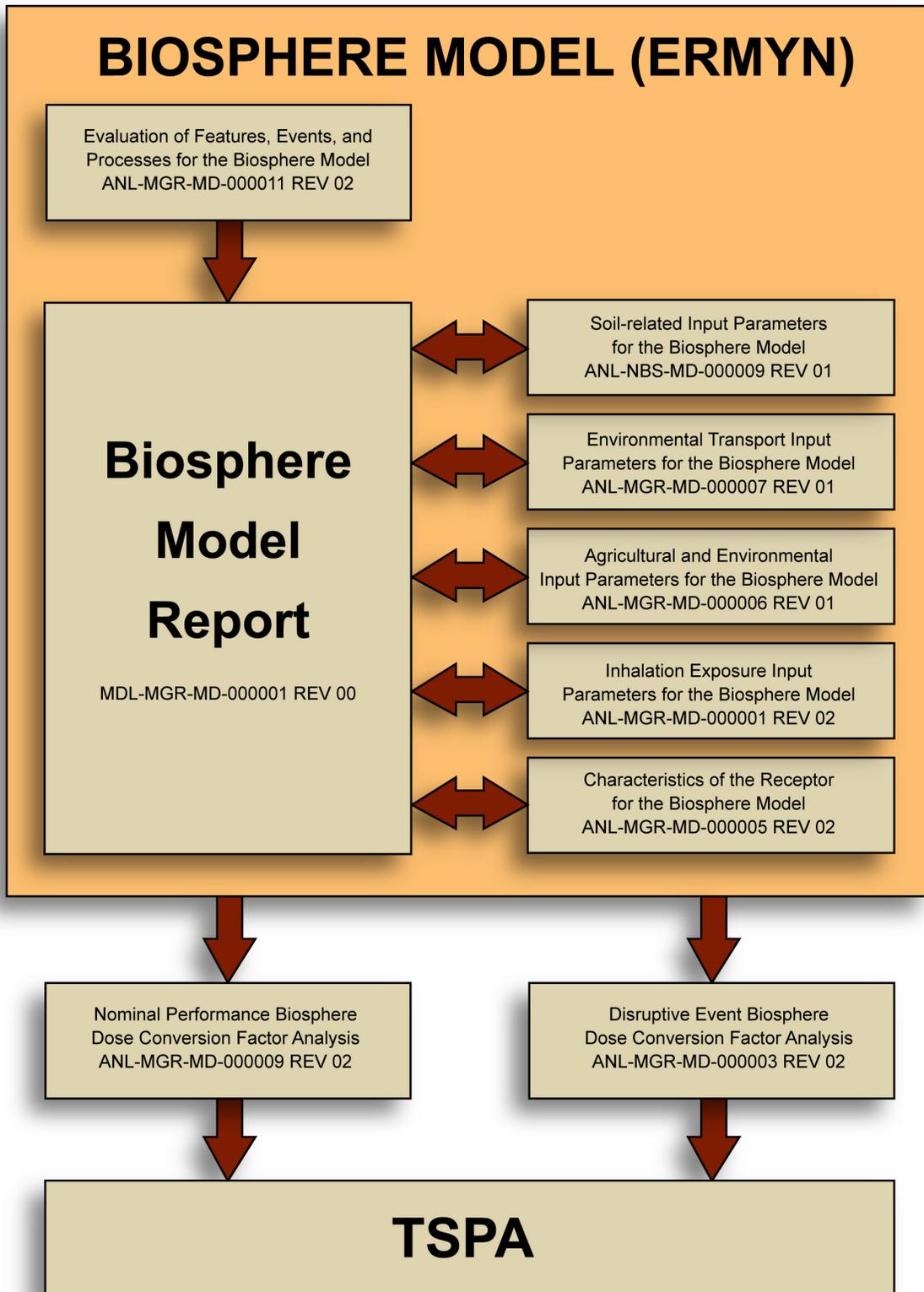


Figure 1. Biosphere Model Documentation

1.1 SCOPE

Technical Work Plan for: Biosphere Modeling and Expert Support (BSC 2002b) identifies the general overall scope of work and objectives for this SAR, including evaluation of the applicability of the biosphere-related primary FEPs. The scope of this SAR is focused on the determination of primary FEP applicability, based on the final regulations promulgated by the NRC at 10 CFR Part 63, and meeting the NRC/DOE Agreed Path Forward concerning biosphere-related FEP issues (Reamer 2001, Attachment 2).

In anticipation of the implementation of The Enhanced FEP Plan (BSC 2002a), the scope of this SAR is limited exclusively to primary FEPs and their descriptions as identified in *The Development of Information Catalogued in REV00 of the YMP FEP Database* (YMP FEP Database) (Freeze et al. 2001). Expected changes to the hierarchical classification structure for FEPs will result in the elimination of secondary FEPs (BSC 2002a, p. 19), and may result in changes to the primary FEP descriptions as well as the creation of new primary FEPs (BSC 2002a, p. 28). Because of the planned elimination of the secondary FEP concept, and for the purpose of simplicity in the analysis of FEPs, secondary FEPs are not considered in the scope of this SAR.

Implementation of the Enhanced FEP Plan (BSC 2002a) and the associated changes to the hierarchical structure of the FEP database may result in an extensive revision to this SAR. As a result, no attempt is made in this document to address the Yucca Mountain Review Plan Acceptance Criteria identified in Section III-6 of Addendum E of *Technical Work Plan for: Biosphere Modeling and Expert Support* (BSC 2002b).

The results of this analysis will be used to support the development of the biosphere model as identified in *Technical Work Plan for: Biosphere Modeling and Expert Support* (BSC 2002b). This SAR will be revised, at a future date, to support the subsequent revision of the YMP FEP Database (Freeze et al. 2001).

1.2 DEVELOPMENT OF FEATURES, EVENTS, AND PROCESSES

The YMP FEP Database (Freeze et al. 2001) provides a list of FEPs that are potentially applicable to the YMP. A detailed summary of the development of that list of FEPs and its structure is presented in the YMP FEP Database (Freeze et al. 2001). Table 1 lists those primary biosphere-related FEPs identified by Freeze et al. (2001) and Reamer (2001, Attachment 2) that are considered in this SAR.

Table 1. Biosphere Features, Events, and Processes

FEP NAME	FEP NUMBER
Ashfall ⁽⁺⁾	1.2.04.07.00
Erosion/denudation	1.2.07.01.00
Deposition	1.2.07.02.00
Climate change, global	1.3.01.00.00
Periglacial effects	1.3.04.00.00
Glacial and ice sheet effects, local	1.3.05.00.00
Water Table Rise ⁽⁺⁾	1.3.07.02.00
Human influences on climate	1.4.01.00.00
Greenhouse gas effects	1.4.01.02.00
Acid rain	1.4.01.03.00
Ozone layer failure	1.4.01.04.00
Altered soil or surface water chemistry	1.4.06.01.00
Water management activities	1.4.07.01.00
Wells	1.4.07.02.00
Social and institutional developments	1.4.08.00.00
Technological developments	1.4.09.00.00
Species evolution	1.5.02.00.00
Capillary rise	2.2.07.03.00
Groundwater chemistry/composition in the Unsaturated and Saturated Zones ⁽⁺⁾	2.2.08.01.00
Radionuclide solubility limits in the Geosphere ⁽⁺⁾	2.2.08.07.00
Distribution and Release of Nuclides from the Geosphere ⁽⁺⁾	2.2.08.11.00
Soil type	2.3.02.01.00
Radionuclide accumulation in soils	2.3.02.02.00
Soil and sediment transport	2.3.02.03.00
Surface water transport and mixing	2.3.04.01.00
Marine features	2.3.06.00.00
Animal burrowing/intrusion	2.3.09.01.00
Precipitation	2.3.11.01.00
Surface runoff and flooding	2.3.11.02.00
Groundwater Discharge to the Surface ⁽⁺⁾	2.3.11.04.00
Biosphere characteristics	2.3.13.01.00
Biosphere transport	2.3.13.02.00
Human characteristics (physiology, metabolism)	2.4.01.00.00
Diet and fluid intake	2.4.03.00.00
Human lifestyle	2.4.04.01.00
Dwellings	2.4.07.00.00
Wild and natural land and water use	2.4.08.00.00
Agricultural land use and irrigation	2.4.09.01.00
Animal farms and fisheries	2.4.09.02.00
Urban and industrial land and water use	2.4.10.00.00
Radioactive Decay and In-growth ⁽⁺⁾	3.1.01.01.00
Drinking water, foodstuffs and drugs, contaminant concentrations in	3.3.01.00.00
Plant uptake	3.3.02.01.00
Animal uptake	3.3.02.02.00

Table 1. Biosphere Features, Events, and Processes (Continued)

FEP NAME	FEP NUMBER
Bioaccumulation	3.3.02.03.00
Contaminated non-food products and exposure	3.3.03.01.00
Ingestion	3.3.04.01.00
Inhalation	3.3.04.02.00
External exposure	3.3.04.03.00
Radiation doses	3.3.05.01.00
Radiological toxicity/effects	3.3.06.00.00
Sensitization to radiation	3.3.06.02.00
Non-radiological toxicity/effects	3.3.07.00.00
Radon and radon daughter exposure	3.3.08.00.00

NOTE: ⁽⁴⁾ From Attachment 2 of Reamer (2001)

2. QUALITY ASSURANCE

This analysis was determined to be quality-affecting in accordance with AP-2.21Q, *Quality Determination and Planning for Scientific, Engineering, and Regulatory Compliance Activities*, because the information will be used to support performance assessment and other quality-affecting activities. AP-2.21Q has been superseded by AP-2.27Q, *Planning for Science Activities*, which will be used to determine the quality-affecting status of subsequent revisions to this report. This analysis is subject to the requirements of *Quality Assurance Requirements and Description* (DOE 2002a) and is covered by *Technical Work Plan for Biosphere Modeling and Expert Support* (BSC 2002b). The primary implementing procedure for this work is Office of Civilian Radioactive Waste Management procedure AP-SIII.9Q *Scientific Analyses*. Several other procedures were used to support development of this analysis. These include the following:

- ÷ AP-2.1Q, *Indoctrination and Training of Personnel*
- ÷ AP-2.2Q, *Establishment and Verification of Required Education and Experience of Personnel*
- ÷ AP-2.14Q, *Review of Technical Products and Data*
- ÷ AP-17.1Q, *Record Source Responsibilities for Inclusionary Records*
- ÷ AP-SI.1Q, *Software Management*
- ÷ AP-SV.1Q, *Control of the Electronic Management of Information*

Personnel performing work on this analysis were trained and qualified according to AP-2.1Q, *Indoctrination and Training of Personnel*, and AP-2.2Q, *Establishment and Verification of Required Education and Experience of Personnel*. Preparation of this analysis does not require the classification of items in accordance with AP-2.22, *Classification Criteria and Maintenance of the Monitored Geologic Repository Q-List*. Methods used to control the electronic

management of information were done in accordance with AP-SV.1Q, as specified in *Technical Work Plan for Biosphere Modeling and Expert Support* (BSC 2002b).

3. USE OF SOFTWARE

This SAR uses no computational software. As a result, these analyses are not subject to software controls. This SAR was developed using only Microsoft Word software for word processing. This software is exempt from qualification requirements in accordance with AP-SI.1Q, *Software Management*. No additional applications, routines, or macros were developed using this software.

4. INPUTS

4.1 DATA AND PARAMETERS

No data or parameters were used in the preparation of this SAR.

4.2 CRITERIA

Regulations promulgated by the NRC at 10 CFR Part 63 provide the regulatory requirements for evaluating the applicability of FEPs to be considered in the assessment of the performance of the proposed repository. These regulatory requirements, referred to as criteria in this SAR, provide specific requirements for the performance objectives (10 CFR 63.113) and performance requirements (10 CFR 63.114) for the repository after permanent closure. 10 CFR 63.311 provides a postclosure individual protection standard, considered as a criterion in this SAR, that the DOE must demonstrate is not exceeded. This standard limits the annual dose to the reasonably maximally exposed individual (RMEI) to not more than 15 mrem. Requirements for the characteristics and limits of the reference biosphere and receptor of interest to be considered are provided in 10 CFR 63.305 and 63.312, respectively. For the purpose of this analysis, the requirements in sections 63.305 and 63.312 are referred to as qualitative criteria. The technical justifications for exclusion of a FEP from consideration on the basis of either low probability or low consequence are provided in 10 CFR 63.114 and are referred to as technical criteria.

4.2.1 Technical Criteria

This analysis applies the technical criteria for exclusion of a FEP from consideration on the basis of either low probability or low consequence. Specifically, the requirements allow a FEP to be excluded from consideration if it is of low probability (i.e., less than one chance in 10,000 of occurring in 10,000 years) or if occurrence of the FEP can be shown to have no significant effect on expected annual dose. The low probability requirement in 10 CFR 63.114(d) explicitly states that the DOE must “Consider only events that have at least one chance in 10,000 of occurring over 10,000 years.”

The requirement for exclusion on the basis of low consequence is provided in 10 CFR 63.114(e), which states:

Provide the technical basis for either inclusion or exclusion of specific features, events, and processes of the geologic setting in the performance assessment. Specific features, events, and processes of the geologic setting must be evaluated in detail if the magnitude and time of the resulting radiological exposures to the reasonably maximally exposed individual, or radionuclide releases to the accessible environment would be significantly changed by their omission.

4.2.2 Qualitative Criteria

The qualitative criteria that define the nature of the environment in which the receptor resides and the characteristics of the receptor of interest are provided in 10 CFR 63.305 and 63.312, respectively.

4.2.2.1 Reference Biosphere

The requirements pertaining to the characteristics of the reference biosphere are presented in 10 CFR 63.305. These requirements are as follows:

- a. Features, events, and processes that describe the reference biosphere shall be consistent with present knowledge of the conditions in the region surrounding the Yucca Mountain site.
- b. DOE should not project changes in society, the biosphere (other than climate), human biology, or increases or decreases in human knowledge or technology. In all analyses done to demonstrate compliance with this part, DOE must assume that all of those factors remain constant as they are at the time of submission of the license application.
- c. DOE must vary factors related to the geology, hydrology, and climate based upon cautious, but reasonable assumptions consistent with present knowledge of factors that could affect the Yucca Mountain disposal system over the next 10,000 years.
- d. Biosphere pathways must be consistent with arid or semi-arid conditions.

4.2.2.2 Reasonably Maximally Exposed Individual

The requirements pertaining to the characteristics of the RMEI are presented in 10 CFR 63.312. These requirements are as follows:

The reasonably maximally exposed individual is a hypothetical person who meets the following criteria:

- a. Lives in the accessible environment above the highest concentration of radionuclides in the plume of contamination;

- b. Has a diet and living style representative of the people who now reside in the Town of Amargosa Valley, Nevada. DOE must use projections based on surveys of the people residing in the Town of Amargosa Valley, to determine their current diets and living styles and use the mean values of these factors in the assessments conducted for Subsections 63.311 and 63.321;
- c. Uses well water with average concentrations of radionuclides based on an annual water demand of 3000 acre-feet;
- d. Drinks 2 liters of water per day from wells drilled into the ground water at the location specified in paragraph (a) of this section; and
- e. Is an adult with metabolic and physiological considerations consistent with present knowledge of adults.

4.3 CODES AND STANDARDS

There are no Codes or Standards directly applicable to this analysis.

5. ASSUMPTIONS

No assumptions were used in the analysis of FEPs applicability.

6. SCIENTIFIC ANALYSIS DISCUSSION

This section documents the screening analysis of FEPs that are identified as biosphere-related in Table 1 of this SAR.

6.1 SCREENING AND ANALYSIS OF THE BIOSPHERE-RELATED PRIMARY FEATURES, EVENTS, AND PROCESSES

The primary method used in this analysis was a comparison of the biosphere-related primary FEPs descriptions with the screening criteria identified in Section 4.2. The FEP descriptions, as presented in Section 6.2, are taken directly from the YMP FEP Database (Freeze et al. 2001).

For each FEP, the screening argument includes a reference to the section or subsection of 10 CFR Part 63 upon which the inclusion or exclusion is based. A short discussion of the reason for inclusion or exclusion is included to support the screening argument. For those that were excluded based on probability or consequence criteria, the screening argument includes a summary of the basis that indicates either low probability or low consequence.

The 54 primary FEPs identified in Table 1 of this SAR were screened for inclusion or exclusion based on criteria identified in Section 4.2 of this SAR. A primary FEP was screened as “include” if the primary FEP description was determined to be potentially applicable to the proposed repository at Yucca Mountain.

6.2 BIOSPHERE FEP EVALUATION AND ANALYSIS

6.2.1 Ashfall (FEP 1.2.04.07.00)

FEP Description: Finely-divided waste particles are carried up a volcanic vent and deposited at land surface from an ash cloud or pyroclastic flow.

Screening Decision and Regulatory Basis: Include contaminated ash deposited in the vicinity of the RMEI as a result of volcanic eruptions, as per the requirements of 10 CFR 63.114(d).

Screening Argument: The probability of a volcanic event intersecting the proposed repository at Yucca Mountain, as represented by the mean value of the aggregate probability distribution, is 1.5×10^{-8} dike intersections per year (CRWMS M&O 2000a, Section 6.3.1.5.). This annual probability exceeds the exclusion criteria in 10 CFR 63.114(d); therefore this FEP is included. Radionuclides in the contaminated volcanic ash may be incorporated into the food chain, may be inhaled, and/or result in external radiation doses.

6.2.2 Erosion/denudation (FEP 1.2.07.01.00)

FEP Description: Erosion and denudation are processes, which cause significant changes in the present-day topography and thus affect local and regional hydrology and the biosphere. Erosion of surficial materials can occur by a variety of means, including physical weathering (including glacial and fluvial erosion), chemical weathering, erosion by wind (aeolian erosion), and mass wasting (e.g., landslide) processes. The extent of erosion depends to a large extent on climate and uplift.

Screening Decision and Regulatory Basis: Include those erosional processes that are consistent with present knowledge of the conditions surrounding the Yucca Mountain site, as per 10 CFR 63.305(a).

Exclude glacial erosion on the basis of inconsistency with the requirements of 10 CFR 63.305(a) and (c).

Screening Argument: The youngest stratigraphic units in the vicinity of Yucca Mountain are predominately alluvium, colluvium and eolian deposits which indicate that erosion and deposition are processes that have occurred and are currently occurring (DOE 2002b, p. 3-52). Therefore, this FEP is included as per 10 CFR 63.305(a).

The current climate of the region around Yucca Mountain is characterized by average temperatures that exceed 0°C. (DOE

2002b, p. 3-15). Therefore, glacial erosion is excluded on the basis of inconsistency with present knowledge of conditions in the region surrounding the Yucca Mountain site, as per 10 CFR 63.305(a).

Future climate forecasts, based on the analysis of paleoclimatic conditions that occurred in the Yucca Mountain region (USGS 2001, Section 6.6), indicate that the climate will evolve to a cooler, wetter climate over the next 10,000 years. These conditions will be those of a glacial transition climate. A full glacial climatic state is not expected within the next 38,000 years (Sharpe 2002, Table 6-6). As a result, glacial erosion is a process that is excluded on the basis of not being consistent with present knowledge of factors that could affect the Yucca Mountain disposal system over the next 10,000 years as is required in 10 CFR 63.305(c).

6.2.3 Deposition (FEP 1.2.07.02.00)

FEP Description:

Deposition and erosion are processes, which cause significant changes in the present-day topography and thus affect local and regional hydrology and the biosphere. Deposition of surficial materials can occur by a variety of means, including fluvial, aeolian, and lacustrine deposition and redistribution of soil through weathering and mass wasting processes.

Screening Decision and Regulatory Basis:

Include those depositional and erosional processes that are consistent with present knowledge of the conditions surrounding the Yucca Mountain site, as per 10 CFR 63.305(a) and (c).

Screening Argument:

The youngest stratigraphic units in the vicinity of Yucca Mountain are predominately alluvium, colluvium and eolian deposits which indicate that erosion, and subsequent deposition, are processes that have occurred and are currently occurring (DOE 2002b, pp. 3-52). Therefore, this FEP is included as per 10 CFR 63.305(a).

The region around Yucca Mountain lacks permanent surface water bodies. Section 7.1 of *Yucca Mountain Site Description* (CRWMS M&O 2000b) and Figure 2-2 of *Information and Analyses to Support Selection of Critical Groups and Reference Biospheres for Yucca Mountain Exposure Scenarios* (LaPlante and Poor 1997) indicate there are no perennial lakes and rivers within approximately 40 km of the location of Yucca Mountain. Under these current climatic conditions, lacustrine deposition can be excluded because it is inconsistent with present knowledge of conditions surrounding the Yucca Mountain site, as per 10 CFR 63.305(a).

Future climate forecasts based on the analysis of paleoclimatic conditions that occurred in the Yucca Mountain region (USGS 2001, Section 6.6), indicate that the climate will evolve to a cooler, wetter climate over the next 10,000 years. These conditions will be those of a glacial transition climate. Estimates of the effect of this climatic change (DOE 2002b, p. 3-59) indicate that the regional groundwater table could rise between 50 and 130 meters. Given depth to groundwater shown in Figure 2-2 of *Information and Analyses to Support Selection of Critical Groups and Reference Biospheres for Yucca Mountain Exposure Scenarios* (LaPlante and Poor 1997) and the possible paleo-discharge locations identified in *Simulated Effects of Climate Change on the Death Valley Regional Ground-Water Flow System, Nevada and California* (D'Agnese et al. 1999, p. 6), fluvial and lacustrine deposition are included for future climatic conditions consistent with 10 CFR 63.305(c).

6.2.4 Climate Change, Global (FEP 1.3.01.00.00)

FEP Description:

Climate change may affect the long-term performance of the repository. This includes the effects of long-term change in global climate (e.g., glacial/interglacial cycles) and shorter-term change in regional and local climate. Climate is typically characterized by temporal variations in precipitation and temperature.

*Screening Decision
and Regulatory Basis:*

Include on the basis of the requirements of 10 CFR 63.305(c).

Screening Argument:

Future climate forecasts (USGS 2001, Section 6.6) indicate that the climate is reasonably expected to evolve to the cooler, wetter conditions of a glacial transition climate within the 10,000-year compliance period. Monsoon and Intermediate states are predicted to last until 38,000 years A.P. (Sharpe 2002, Table 6-6). Therefore, this FEP is included on the basis of the requirements of 10 CFR 63.305(c) that requires the DOE to vary factors related to climate based on cautious, but reasonable assumptions.

6.2.5 Periglacial Effects (FEP 1.3.04.00.00)

FEP Description:

This category contains FEPs related to the physical processes and associated landforms in cold but ice-sheet-free environments. Permafrost and seasonal freeze/thaw cycles are characteristic of periglacial environments.

*Screening Decision
and Regulatory Basis:*

Exclude on the basis of inconsistency with present knowledge of conditions in the region surrounding the Yucca Mountain site, as

per 10 CFR 63.305(a) and reasonable assumptions consistent with present knowledge of factors that could affect the Yucca Mountain disposal system over the next 10,000 years, as per 10 CFR 63.305(c).

Screening Argument:

The current climate of the region around Yucca Mountain is characterized by average temperatures that exceed 0°C. (DOE 2002b, pp. 3-15). Therefore, this FEP is excluded on the basis of inconsistency with present knowledge of conditions in the region surrounding the Yucca Mountain site, as per 10 CFR 63.305(a).

Future climate forecasts estimate that the climate around Yucca Mountain will evolve to a cooler, wetter glacial transition state within the next 10,000 years (USGS 2001, Section 6.6). The lower bound of the mean average temperature range for the glacial transition state (USGS 2001, Section 6.6) is above the temperature needed to support periglacial effects. Monsoon and Intermediate states are predicted to last until 38,000 years A.P. (Sharpe 2002, Table 6-6). As a result, periglacial effects are not credible. Therefore, this FEP is excluded on the basis of inconsistency with reasonable assumptions consistent with present knowledge of factors that could affect the Yucca Mountain disposal system over the next 10,000 years, as per 10 CFR 63.305(c).

6.2.6 Glacial and Ice Sheet Effects, Local (FEP 1.3.05.00.00)

FEP Description:

This category contains FEPs related to the effects of glaciers and ice sheets occurring within the region of the repository, including direct geomorphologic effects and hydrologic effects. These effects include changes in topography (due to glaciation and melt water), changes in flow fields, and isostatic depression and rebound.

*Screening Decision
and Regulatory Basis:*

Exclude on the basis of inconsistency with present knowledge of conditions in the region surrounding the Yucca Mountain site, as per 10 CFR 63.305(a) and reasonable assumptions consistent with present knowledge of factors that could affect the Yucca Mountain disposal system over the next 10,000 years, as per 10 CFR 63.305(c).

Screening Argument:

The current climate of the region around Yucca Mountain is characterized by average temperatures that exceed 0°C. (DOE 2002b, pp. 3-15). Therefore, this FEP is excluded on the basis of inconsistency with present knowledge of conditions in the region surrounding the Yucca Mountain site, as per 10 CFR 63.305(a).

Future climate forecasts (USGS 2001, Section 6.6) indicate that the climate is expected to evolve to a cooler and wetter climate over the next 10,000 years. The lower bound of the mean average temperature range for this cooler and wetter glacial transition state (USGS 2001, Section 6.6) is projected to be above the temperature needed to support glaciers or ice sheets. Monsoon and Intermediate states are predicted to last until 38,000 years A.P. (Sharpe 2002, Table 6-6). Therefore, this FEP is excluded on the basis of its inconsistency with reasonable assumptions consistent with present knowledge of factors that could affect the Yucca Mountain disposal system over the next 10,000 years, as per 10 CFR 63.305(c).

6.2.7 Water Table Rise (FEP 1.3.07.02.00)

FEP Description:

Climate change could produce increased infiltration, leading to a rise in the regional water table, possibly affecting the release and exposure pathways from the potential repository. A regionally higher water table and change in flow patterns might move discharge points closer to the potential repository, or flood the potential repository.

Screening Decision and Regulatory Basis:

Include water table rise as a result of climate change on the basis of the requirements of 10 CFR 63.305(c).

Exclude potential impacts of water table rise on the repository as per the requirements of 10 CFR 63.305(a).

Screening Argument:

Modeling of the effects of climatic change on the groundwater flow system around Yucca Mountain indicates that a change to wetter climate will result in an increase in the groundwater elevation (D'Agnese et al. 1999, p. 21).

The forecasted future climate for the Yucca Mountain region is a glacial-transition climate that is wetter, but not substantially wetter than the modern climate (USGS 2001, Section 6.6). Estimates of the effect of this climatic change (DOE 2002b, pp. 3-59) indicate that the regional groundwater table could rise between 50 and 130 meters. Given the depth to groundwater shown in Figure 2-2 of *Information and Analyses to Support Selection of Critical Groups and Reference Biospheres for Yucca Mountain Exposure Scenarios* (LaPlante and Poor 1997) and the possible paleo-discharge locations identified in *Simulated Effects of Climate Change on the Death Valley Regional Ground-Water Flow System, Nevada and California* (D'Agnese et al. 1999, p. 6), water table rise under

future climatic conditions is included consistent with 10 CFR 63.305(c).

Potential impacts of water table rise on the repository are excluded on the basis of inconsistency with 10 CFR 63.305(a), which requires that only FEPs that describe the reference biosphere need to be considered.

6.2.8 Human Influences on Climate (FEP 1.4.01.00.00)

FEP Description: This category contains FEPs related to future human actions that could influence global, regional, or local climate. Human actions may be intentional or accidental. This FEP aggregates all human influences on climate into a single category. Technical discussions are presented separately for increased recharge (1.4.01.01.00), greenhouse gas effects (1.4.01.02.00), acid rain (1.4.01.03.00), and ozone layer failure (1.4.01.04.00).

Screening Decision and Regulatory Basis: Exclude on the basis of the requirements of 10 CFR 63.305(c).

Screening Argument: In their response to comments on climate change (66 FR 55732, p. 55757), the NRC emphasized the importance of including “climate change in both the geosphere and biosphere performance calculations to ensure that the conceptual model of the environment is consistent with our scientific understanding of anticipated natural events.” Similarly, in their background discussion of the specification of a probability for unlikely FEPs, the NRC stated that “DOE’s performance assessments are required to consider the naturally occurring features, events and processes that could affect the performance of a geologic repository...” Based on these statements, the FEPs associated with the characteristics of the reference biosphere under 10 CFR 63.305(a) are limited to naturally occurring FEPs and exclude those FEPs related to human activities. Likewise, those geological, hydrological and climatological FEPs that the DOE must vary under 10 CFR 63.305(c) are also limited to naturally occurring FEPs.

Since this FEP focuses on the consequences of future human activities on climate, it is excluded on the basis of inconsistency with the requirements of 10 CFR 63.305(c).

6.2.9 Greenhouse Gas Effects (FEP 1.4.01.02.00)

FEP Description: The greenhouse effect refers to the presence of carbon dioxide and other gases in the atmosphere that tend to allow solar radiation through to the earth’s surface and reflect heat back to it. Thus,

these gases act much as the glass of a greenhouse, with the earth as the greenhouse. Human activities such as burning of fossil fuels, forest clearance, and industrial processes produce these greenhouse gases. The greenhouse effect could increase concentrations of carbon dioxide and other gases in the atmosphere, and lead to changes in climate such as global warming.

*Screening Decision
and Regulatory Basis:*

Exclude on the basis of the requirements of 10 CFR 63.305(a) and (c).

Screening Argument:

This FEP focuses on the greenhouse effects resulting from human activities. In their response to comments on climate change (66 FR 55732, p. 55757), the NRC emphasized the importance of including “climate change in both the geosphere and biosphere performance calculations to ensure that the conceptual model of the environment is consistent with our scientific understanding of anticipated natural events.” Similarly, in their background discussion of the specification of a probability for unlikely FEPs, the NRC stated that “DOE’s performance assessments are required to consider the naturally occurring features, events and processes that could affect the performance of a geologic repository...” Based on these statements, the FEPs associated with the characteristics of the reference biosphere under 10 CFR 63.305(a) are limited to naturally occurring FEPs and exclude those FEPs related to human activities. Likewise, those geological, hydrological and climatological FEPs that the DOE must vary under 10 CFR 63.305(c) are also limited to naturally occurring FEPs.

Since this FEP focuses on the consequences of human activities on climate, it is excluded on the basis of inconsistency with the requirements of 10 CFR 63.305(a) and (c).

6.2.10 Acid Rain (FEP 1.4.01.03.00)

FEP Description:

Human actions may result in acid rain on a local to regional scale. Acid rain can detrimentally affect aquatic and terrestrial life by interfering with the growth, reproduction and survival of organisms. It can influence the behavior and transport of contaminants in the biosphere, particularly by affecting surface water and soil chemistry.

*Screening Decision
and Regulatory Basis:*

Exclude on the basis of the requirements of 10 CFR 63.305(a) and (c).

Screening Argument:

This FEP focuses on the effects of acid rain resulting from human activities. In their response to comments on climate change (66 FR 55732, p. 55757), the NRC emphasized the importance of including “climate change in both the geosphere and biosphere performance calculations to ensure that the conceptual model of the environment is consistent with our scientific understanding of anticipated natural events.” Similarly, in their background discussion of the specification of a probability for unlikely FEPs, the NRC stated that “DOE’s performance assessments are required to consider the naturally occurring features, events and processes that could affect the performance of a geologic repository...” Based on these statements, the FEPs associated with the characteristics of the reference biosphere under 10 CFR 63.305(a) are limited to naturally occurring FEPs and exclude those FEPs related to human activities. Likewise, those geological, hydrological and climatological FEPs that the DOE must vary under 10 CFR 63.305(c) are also limited to naturally occurring FEPs.

Since this FEP focuses on the consequences of human activities on climate, it is excluded on the basis of inconsistency with the requirements of 10 CFR 63.305(a) and (c).

6.2.11 Ozone Layer Failure (FEP 1.4.01.04.00)

FEP Description:

Human actions (i.e., the use of certain industrial chemicals) may lead to destruction or damage to the earth’s ozone layer. This may lead to significant changes to the climate, affecting properties of the geosphere such as groundwater flow patterns.

*Screening Decision
and Regulatory Basis:*

Exclude on the basis of the requirements of 10 CFR 63.305(a) and (c).

Screening Argument:

This FEP focuses on damage to the earth’s ozone layer as a result of human activities. In their response to comments on climate change (66 FR 55732, p. 55757), the NRC emphasized the importance of including “climate change in both the geosphere and biosphere performance calculations to ensure that the conceptual model of the environment is consistent with our scientific understanding of anticipated natural events.” Similarly, in their background discussion of the specification of a probability for unlikely FEPs, the NRC stated that “DOE’s performance assessments are required to consider the naturally occurring features, events and processes that could affect the performance of a geologic repository...” Based on these statements, the FEPs associated with the characteristics of the reference biosphere under

10 CFR 63.305(a) are limited to naturally occurring FEPs and exclude those FEPs related to human activities. Likewise, those geological, hydrological and climatological FEPs that the DOE must vary under 10 CFR 63.305(c) are also limited to naturally occurring FEPs.

Since this FEP focuses on the consequences of human activities on climate, it is excluded on the basis of inconsistency with the requirements of 10 CFR 63.305(a) and (c).

6.2.12 Altered Soil or Surface Water Chemistry (FEP 1.4.06.01.00)

FEP Description: Human activities (e.g., industrial pollution, agricultural chemicals) may produce local changes to the soil chemistry or to the chemistry of water infiltrating Yucca Mountain and could provide a plume of unspecified nature to interact with the repository and possibly with containers.

Screening Decision and Regulatory Basis: Exclude on the basis of inconsistency with 10 CFR 63.305(c).

Screening Argument: This FEP is focused on the consequences of human actions on groundwater interacting with the repository. In their background discussion of the specification of a probability for unlikely FEPs, the NRC stated that “DOE’s performance assessments are required to consider the naturally occurring features, events and processes that could affect the performance of a geologic repository...” Based on these statements, the FEPs associated with the characteristics of the reference biosphere under 10 CFR 63.305(a) are limited to naturally occurring FEPs and exclude those FEPs related to human activities. Likewise, those geological, hydrological and climatological FEPs that the DOE must vary under 10 CFR 63.305(c) are also limited to naturally occurring FEPs.

Since this FEP focuses the consequences of human activities on the repository, is excluded on the basis of inconsistency with the requirements of 10 CFR 63.305(c).

6.2.13 Water Management Activities (FEP 1.4.07.01.00)

FEP Description: Water management is accomplished through a combination of dams, reservoirs, canals, pipelines, collection and storage facilities. Water management activities could have a major influence on the behavior and transport of contaminants in the biosphere.

*Screening Decision
and Regulatory Basis:*

Exclude on the basis of inconsistency with the requirements of Sections 305(a), 305(b) and 114(e) of 10 CFR 63.

Screening Argument:

Based on Figure 2–2 of *Information and Analyses to Support Selection of Critical Groups and Reference Biospheres for Yucca Mountain Exposure Scenarios* (LaPlante and Poor 1997) and Section 7.1 of *Yucca Mountain Site Description* (CRWMS M&O 2000b), there are no surface water management features such as dams, reservoirs, canals, collection and storage facilities in the region around Yucca Mountain, except for the man-made feature in Ash Meadows. Therefore, surface water management features, except for Ash Meadows, are excluded on the basis of inconsistency with the requirements of 10 CFR 63.305(a).

The facilities at Ash Meadows are fed by groundwaters predominantly from the Ash Meadows Groundwater Basin while the groundwater under Yucca Mountain is within the Alkali Flat-Furnace Creek Groundwater Basin (DOE 2002b, Fig. 3-15). The groundwater elevation decline indicates that the potential groundwater flow is from Ash Meadows towards the Alkali Flat-Furnace Creek groundwater basin, not the opposite (DOE 2002b, pp. 3-46). Therefore, the potential for contamination of Ash Meadows by radionuclides, from Yucca Mountain, in groundwater is not considered credible. As a result, this feature is excluded on the basis of 10 CFR 63.114(e), which requires a FEP to be included if its exclusion would significantly change the magnitude or time of resulting radiological exposure to the RMEI or radionuclide release.

This FEP is exclude from consideration in the future on the basis of 10 CFR 63.305(b), which precludes consideration of changes in society.

Man-made features such as pipelines, storage and collection facilities, and ponds associated with the use of groundwater are considered under FEP 1.4.07.02.00, *Wells*.

6.2.14 Wells (FEP 1.4.07.02.00)

FEP Description:

One or more wells drilled for human use (e.g., drinking water, bathing) or agricultural use (e.g., irrigation, animal watering) may intersect the contaminant plume.

*Screening Decision
and Regulatory Basis:*

Include the use of well water for domestic and agricultural purposes consistent with current human behavior and characteristics as per the requirements of 10 CFR 63.312(c).

Screening Argument:

Section 312(a) of 10 CFR Part 63 requires that the RMEI uses well water with average concentration of radionuclides drilled in the ground water at a location specified in paragraph (a) of this section. Therefore, use of a well is included.

6.2.15 Social and Institutional Developments (FEP 1.4.08.00.00)

FEP Description:

This category contains FEPs related to social and institutional developments that could affect the long-term performance of the repository. The most likely is social and institutional development resulting in new activities, communities or cities in the vicinity of Yucca Mountain.

*Screening Decision
and Regulatory Basis:*

Exclude on the basis of the regulatory requirements in 10 CFR 63.305(b).

Screening Argument:

10 CFR 63.305(b) specifically states that “DOE should not project changes in society, the biosphere (other than climate), human biology, or increases or decreases in human knowledge or technology. In all analyses done to demonstrate compliance with this part, the DOE must assume that all of those factors remain constant as they are at the time of submission of the license application.” Therefore, change in the social and institutional attributes of society is excluded on the basis of the regulatory requirements in 10 CFR 63.305(b).

6.2.16 Technological Developments (FEP 1.4.09.00.00)

FEP Description:

Technological developments may affect the long-term performance of the repository. These include changes in the ability of man to intrude the site, and changes that might affect contaminant exposure and its health implications.

*Screening Decision
and Regulatory Basis:*

Exclude on the basis of the regulatory requirements in 10 CFR 63.305(b).

Screening Argument:

10 CFR 63.305(b) specifically states that “DOE should not project changes in society, the biosphere (other than climate), human biology, or increases or decreases in human knowledge or technology. In all analyses done to demonstrate compliance with this part, the DOE must assume that all of those factors remain

constant as they are at the time of submission of the license application.” Therefore, technological development is excluded on the basis of the regulatory requirements in 10 CFR 63.305(b).

6.2.17 Species Evolution (FEP 1.5.02.00.00)

FEP Description: Species living at or near the repository, including humans, may evolve in the future and new behavior and characteristics of living organisms may affect their contaminant exposure and its health implications.

Screening Decision and Regulatory Basis: Exclude on the basis of the regulatory requirements in 10 CFR 63.305(b).

Screening Argument: 10 CFR 63.305(b) specifically states that “DOE should not project changes in society, the biosphere (other than climate), human biology, or increases or decreases in human knowledge or technology. In all analyses done to demonstrate compliance with this part, the DOE must assume that all of those factors remain constant as they are at the time of submission of the license application.” Therefore, species evolution is excluded on the basis of the regulatory requirements in 10 CFR 63.305(b).

6.2.18 Capillary Rise (FEP 2.2.07.03.00)

FEP Description: Capillary rise involves the drawing up of water, above the water table or above locally saturated zones, in continuous pores of the unsaturated zone until the suction gradient is balanced by the gravitational pull downward. Capillary rise may provide a mechanism for radionuclides to reach the surface environment in locations where the water table is shallow.

Screening Decision and Regulatory Basis: Include as per the requirements of 10 CFR 63.305(c).

Screening Argument: Modeling of the effects of climatic change on the groundwater flow system around Yucca Mountain indicates that a change to wetter climate will result in an increase in the groundwater elevation (D’Agnese et al. 1999, p. 21).

The forecasted future climate for the Yucca Mountain region is a glacial-transition climate that is wetter, but not substantially wetter than the modern climate (USGS 2001, Section 6.6). Estimates of the effect of this climatic change (DOE 2002b, p. 3-59) indicate that the regional groundwater table could rise between 50 and 130 meters. Given the depth to groundwater shown in Figure 2-2 of *Information and Analyses to Support Selection of Critical Groups*

and Reference Biospheres for Yucca Mountain Exposure Scenarios (LaPlante and Poor 1997) and the possible paleo-discharge locations identified in *Simulated Effects of Climate Change on the Death Valley Regional Ground-Water Flow System, Nevada and California* (D'Agnese et al. 1999, p. 6), water table rise under future climatic conditions is included consistent with 10 CFR 63.305(c).

6.2.19 Groundwater Chemistry/Composition in the Unsaturated and Saturated Zone (FEP 2.2.08.01.00)

FEP Description: Chemistry and the characteristics of groundwater in the saturated and unsaturated zones may affect groundwater flow and radionuclide transport. Groundwater chemistry and other characteristics, including temperature, pH, Eh, ionic strength, and major ionic concentrations, may vary spatially throughout the system as a result of different rock mineralogy, and may also change through time, as a result of the evolution of the disposal system or from mixing with other waters.

Screening Decision and Regulatory Basis: Exclude processes that effect radionuclide transport in the saturated and unsaturated zones on the basis of the requirements of 10 CFR 63.305(a).

Screening Argument: Although these processes influence which radionuclides may reach the biosphere, these processes do not “describe the reference biosphere” as required in 10 CFR 63.305(a). As a result, this FEP is excluded. Similar chemical processes that influence radionuclide transport in the biosphere are addressed by FEP 2.3.13.02.00, *Biosphere Transport*.

6.2.20 Radionuclide Solubility Limits in the Geosphere (FEP 2.2.08.07.00)

FEP Description: Solubility limits for radionuclides in geosphere groundwater may be different than in the water in the waste and EBS.

Screening Decision and Regulatory Basis: Exclude radionuclide solubility processes, and differences between the water in the waste and the EBS (Engineered Barrier System), that effect radionuclide solubility in the geosphere on the basis of the requirements of 10 CFR 63.305(a).

Screening Argument: Although these processes influence which radionuclides may reach the location of the RMEI, these processes are specific to the geosphere and do not “describe the reference biosphere” as required in 10 CFR 63.305(a). As a result, this FEP is excluded. Radionuclide solubility processes that influence radionuclide

transport through the biosphere are addressed by FEP 2.3.13.02.00, *Biosphere Transport*.

6.2.21 Distribution and Release of Nuclides from the Geosphere (FEP 2.2.08.11.00)

FEP Description: Radionuclides may be released to the biosphere following groundwater transport in unsaturated and saturated zones.

Screening Decision and Regulatory Basis: Include release of radionuclides from the geosphere into the biosphere via a domestic well as per the requirements of 10 CFR 63.312(c). Include surface expression of groundwater as per the requirements of 10 CFR 63.305(c).

Screening Argument: Include discharge of groundwater into the biosphere via a domestic well. Section 63.312(c) specifies that the RMEI uses a well. This well is considered as the specific entry point of radionuclides into the biosphere.

Modeling of the effects of climatic change on the groundwater flow system around Yucca Mountain indicates that a change to wetter climate will result in an increase in the groundwater elevation (D'Agnese et al. 1999, p. 21).

The forecasted future climate for the Yucca Mountain region is a glacial-transition climate that is wetter, but not substantially wetter than the modern climate (USGS 2001, Section 6.6). Estimates of the effect of this climatic change (DOE 2002b, p. 3-59) indicate that the regional groundwater table could rise between 50 and 130 meters. Given the depth to groundwater shown in Figure 2-2 of *Information and Analyses to Support Selection of Critical Groups and Reference Biospheres for Yucca Mountain Exposure Scenarios* (LaPlante and Poor 1997) and the possible paleo-discharge locations identified in *Simulated Effects of Climate Change on the Death Valley Regional Ground-Water Flow System, Nevada and California* (D'Agnese et al. 1999, p. 6), groundwater discharge into lakes, wetlands, springs under future climatic conditions is included consistent with 10 CFR 63.305(c).

6.2.22 Soil Type (FEP 2.3.02.01.00)

FEP Description: Soil type is determined by many different factors (e.g., formative process, geology, climate, vegetation, land-use). The physical and chemical attributes of the surficial soils (such as organic matter content, pH), may influence the mobility of contaminants.

Screening Decision and Regulatory Basis: Include as per the requirements of 10 CFR 63.305(a).

Screening Argument: Soil is a feature that describes part of the reference biosphere and is therefore included as per the requirements of 10 CFR 63.305(a).

6.2.23 Radionuclide Accumulation in Soil (FEP 2.3.02.02.00)

FEP Description: Radionuclide accumulation in soils may occur as a result of upwelling of contaminated groundwater (leaching, evaporation at discharge location) or deposition of contaminated water or particulates (irrigation water, runoff, atmospheric deposition).

Screening Decision and Regulatory Basis: Include radionuclide accumulation in soil as per the requirements of 10 CFR 63.305(a) and (c).

Screening Argument: Radionuclide accumulation in soil, as a result of long-term irrigation, is an integral process in the modeling of the reference biosphere and is included as per the requirements of 10 CFR 63.305(a) and (c).

6.2.24 Soil and Sediment Transport (FEP 2.3.02.03.00)

FEP Description: Contaminated sediments can be transported by fluvial, glacial and, to a lesser extent, aeolian processes. In addition, sediment transport may occur through the actions of living organisms (i.e., bioturbation). Sediment transport and redistribution may cause concentration or dilution of radionuclides.

Screening Decision and Regulatory Basis: Include soil and sediment transport as per 10 CFR 305(a).
Exclude glacial transport of sediments on the basis of 10 CFR 63.305(a) and (c).

Screening Argument: Soil and sediment transport are processes currently occurring in the Yucca Mountain region and are included as per 10 CFR 305(a).

The environment around Yucca Mountain does not contain any glaciers at the present time (DOE 2002b, Chapter 3). Therefore, glacial transport of sediments is excluded on the basis of inconsistency with present knowledge of conditions in the region surrounding the Yucca Mountain site, as per 10 CFR 63.305(a).

The region around Yucca Mountain lacks permanent surface water bodies. Section 7.1 of *Yucca Mountain Site Description* (CRWMS M&O 2000b) and Figure 2–2 of *Information and Analyses to Support Selection of Critical Groups and Reference Biospheres for Yucca Mountain Exposure Scenarios* (LaPlante and Poor 1997) indicate there are no perennial rivers within approximately 40 km

of the location of Yucca Mountain. As a result, fluvial transport is excluded on the basis of inconsistency with the requirements of 10 CFR 63.305(a).

Future climate forecasts indicate that the climate will evolve to a cooler and wetter climatic state within the next 10,000 years (USGS 2001, Section 6.6). This cooler, wetter climate will be a glacial transition climate that is not cold enough to support glaciers. Monsoon and Intermediate states are predicted to last until 38,000 years A.P. (Sharpe 2002, Table 6-6). Therefore, glacial transport of soil and sediments is not considered credible and this FEP is excluded on the basis that it is not a reasonable assumption consistent with present knowledge of factors that could affect the Yucca Mountain site as per 10 CFR 63.305(c).

However, estimates of the effect of this climatic change (DOE 2002b, p. 3-59) indicate that the regional groundwater table could rise between 50 and 130 meters. Given the depth to groundwater shown in Figure 2-2 of *Information and Analyses to Support Selection of Critical Groups and Reference Biospheres for Yucca Mountain Exposure Scenarios* (LaPlante and Poor 1997) and the possible paleo-discharge locations identified in *Simulated Effects of Climate Change on the Death Valley Regional Ground-Water Flow System, Nevada and California* (D'Agnesse et al. 1999, p. 6), fluvial transport is included for future climatic conditions consistent 10 CFR 63.305(c).

6.2.25 Surface Water Transport and Mixing (FEP 2.3.04.01.00)

FEP Description:

Contaminants released from an underground repository might enter the biosphere through discharge of deep groundwater into a lake or river. Transport and mixing within the surface water bodies affects the subsequent behavior and transport of contaminants in the biosphere. Transport and mixing includes dilution, sedimentation, aeration, streamflow, and river meander.

Screening Decision and Regulatory Basis:

Exclude surface water transport under current climatic conditions on the basis of 10 CFR 63.305(a) and include surface water transport under future climatic conditions on the basis of 10 CFR 63.305(c).

Screening Argument:

The region around Yucca Mountain lacks permanent surface water bodies. Section 7.1 of *Yucca Mountain Site Description* (CRWMS M&O 2000b) and Figure 2-2 of *Information and Analyses to Support Selection of Critical Groups and Reference Biospheres for Yucca Mountain Exposure Scenarios* (LaPlante and Poor 1997)

indicate there are no perennial lakes and rivers within approximately 40 km of the location of Yucca Mountain. As a result, this FEP is excluded on the basis of inconsistency with the requirements of 10 CFR 63.305(a).

Future climate forecasts, based on the analysis of paleoclimatic conditions that occurred in the Yucca Mountain region (USGS 2001, Section 6.6), indicate that the climate will evolve to a cooler, wetter climate over the next 10,000 years. These conditions will be those of a glacial transition climate. Monsoon and Intermediate states are predicted to last until 38,000 years A.P. (Sharpe 2002, Table 6-6).

Estimates of the effect of this climatic change (DOE 2002b, p. 3-59) indicate that the regional groundwater table could rise between 50 and 130 meters. Given the depth to groundwater shown in Figure 2-2 of *Information and Analyses to Support Selection of Critical Groups and Reference Biospheres for Yucca Mountain Exposure Scenarios* (LaPlante and Poor 1997) and the possible paleo-discharge locations identified in *Simulated Effects of Climate Change on the Death Valley Regional Ground-Water Flow System, Nevada and California* (D'Agnese et al. 1999, p. 6), surface water transport is included for future climatic conditions consistent 10 CFR 63.305(c).

6.2.26 Marine Features (FEP 2.3.06.00.00)

FEP Description: This category contains FEPs related to marine and coastal features and processes. Processes include erosion, sedimentation, deposition, sea-level change, and storms.

Screening Decision and Regulatory Basis: Exclude on the basis of 10 CFR 63.305(a) and (c).

Screening Argument: Figure 1.1-1 of the *Yucca Mountain Site Description* (CRWMS M&O 2000b, p. F1.1-1) shows the location of the Yucca Mountain region relative to the continental boundaries of the United States. Given the location of Yucca Mountain, the potential for impact of coastal and/or marine features and processes on the area around Yucca Mountain is not considered as credible. As a result, this FEP is excluded on the basis of inconsistency with the requirements of 10 CFR 63.305(a).

Future climate forecasts based on the analysis of paleoclimatic conditions that have occurred in the Yucca Mountain region (USGS 2001, Section 6.6) indicate that the climate will evolve to a cooler, wetter climate over the next 10,000 years. These

conditions will be those of a glacial transition climate. Monsoon and Intermediate states are predicted to last until 38,000 years A.P. (Sharpe 2002, Table 6-6).

Although this climate is cooler and slightly wetter than the current interglacial climate, the change is expected to have no effect on current coastlines relative to Yucca Mountain. Therefore this FEP can be excluded on the basis of inconsistency with the requirements of 10 CFR 63.305(c).

6.2.27 Animal Burrowing/Intrusion (FEP 2.3.09.01.00)

FEP Description: Burrowing animals may intrude into the repository, promoting release and spread of contamination. Burrowing animals may also contact or ingest contaminated soil.

Screening Decision and Regulatory Basis: Exclude animals burrowing into the repository on the basis of 10 CFR 63.305(a). Exclude non-human contact with or ingestion of contaminated soil on the basis of the performance standard in 10 CFR 63.311.

Screening Argument: Construction plans for the repository, as presented in *Site Recommendation Subsurface Layout* (CRWMS M&O 2000c, p. 34), indicate that the subsurface emplacement level of the repository will be constructed at a depth of not less than 200 meters below the directly overlying ground surface. Wildlife in the region of Yucca Mountain is dominated by species associated with the Mojave Desert (DOE 2002b, Section 3.1.5.1.2). Of the animals identified in this section, none are known to burrow to these depths. Therefore, intrusion by a burrowing animal that leads to contact with or ingestion of contaminated soil is inconsistent with 10 CFR 63.305(a). Consideration of animal ingestion of contaminated soil is included in FEP 2.4.09.02.00, *Animal Farms and Fisheries*.

10 CFR 63.311 specifically limits the performance objective to a dose to man. Therefore, consideration of non-human dose as a measure of performance is excluded on the basis of the regulation.

6.2.28 Precipitation (FEP 2.3.11.01.00)

FEP Description: Precipitation is an important control on the amount of recharge. It transports solutes with it as it flows downward through the subsurface or escapes as runoff. The amount of precipitation depends on climate.

Screening Decision and Regulatory Basis: Include precipitation consistent with the requirements of 10 CFR 63.305(a).

Screening Argument: Although precipitation levels are low, ranging between 4 to 10 inches per year (DOE 2002b, Section 3.1.2.2), this FEP is included because it is consistent with the requirements of 10 CFR 305(a).

6.2.29 Surface Runoff and Flooding (FEP 2.3.11.02.00)

FEP Description: Surface runoff and evapotranspiration are components in the water balance, together with precipitation and infiltration. They can also be important vehicles for the dispersion of contaminants. Surface runoff produces erosion, and can feed washes, arroyos, and impoundments, where flooding may lead to increased recharge.

Screening Decision and Regulatory Basis: Include surface runoff and evapotranspiration consistent with the requirements of 10 CFR 63.305(a).

Screening Argument: Surface runoff, evapotranspiration, and flooding are processes currently occurring in the region around Yucca Mountain, and are included with the requirements of 10 CFR 63.305(a).

6.2.30 Groundwater Discharge to the Surface (FEP 2.3.11.04.00)

FEP Description: Radionuclides transported in groundwater as solutes or solid materials (colloids) from the far field to the biosphere will discharge at specific “entry” points in the biosphere. Surface discharge points may be surface water bodies (rivers, lakes), wetlands, or unsaturated terrestrial soils.

Screening Decision and Regulatory Basis: Exclude groundwater discharge into surface water bodies, wetlands, etc., under current climatic conditions, on the basis of 10 CFR 63.305(a). Include groundwater discharge to the surface under future climatic conditions based on the requirements of 10 CFR 63.305(c).

Screening Argument: The region around Yucca Mountain lacks permanent surface water bodies. Section 7.1 of *Yucca Mountain Site Description* document (CRWMS M&O 2000b) and Figure 2-2 of *Information and Analyses to Support Selection of Critical Groups and Reference Biospheres for Yucca Mountain Exposure Scenarios* (LaPlante and Poor 1997) indicate there are no perennial lakes and rivers within approximately 40 km of the location of Yucca Mountain. As a result, contaminants entering the biosphere via groundwater discharge to a river or lake can be excluded on the basis that this

FEP is inconsistent with present knowledge of conditions surrounding the Yucca Mountain site, as per 10 CFR 63.305(a).

Future climate forecasts indicate that the climate will evolve to a cooler and wetter climatic state within the next 10,000 years (USGS 2001, Section 6.6). Estimates of the effect of this climatic change (DOE 2002b, p. 3-59) indicate that the regional groundwater table could rise between 50 and 130 meters. Given the depth to groundwater shown in Figure 2-2 of *Information and Analyses to Support Selection of Critical Groups and Reference Biospheres for Yucca Mountain Exposure Scenarios* (LaPlante and Poor 1997) and the possible paleo-discharge locations identified in *Simulated Effects of Climate Change on the Death Valley Regional Ground-Water Flow System, Nevada and California* (D'Agnese et al. 1999, p. 6), groundwater discharge is included for future climatic conditions consistent 10 CFR 63.305(c).

6.2.31 Biosphere Characteristics (FEP 2.3.13.01.00)

FEP Description:

The conditions that exist in the biosphere are likely to vary over time in a largely unpredictable manner, due to both natural and anthropogenic events and/or processes. These biosphere conditions or characteristics can influence contaminant transport and can affect the long-term performance of the disposal system. Biosphere characteristics include climate, vegetation, plant and animal populations, and microbes.

Screening Decision and Regulatory Basis:

Include biosphere characteristics such as plants and animal populations, and current climatic conditions consistent with the requirements of 10 CFR 63.305(a). Include future climatic conditions as per the requirements of 10 CFR 63.305(c).

Exclude climate change as a result of human actions as per the requirements of 10 CFR 63.305(c).

Screening Argument:

Consideration of those FEPs that describe the reference biosphere and which are consistent with present knowledge of the conditions in the region surrounding the Yucca Mountain site is required under 10 CFR 63.305(a). Biosphere characteristics that are based on cautious but reasonable assumptions consistent with present knowledge of potential changes in geology, hydrology and climate are included in accordance with 10 CFR 63.305(c). Therefore, this FEP is included consistent with that requirement except for anthropogenic future climate change.

This FEP is focused on changes to the characteristics of the biosphere as a result of natural and anthropogenic events and processes. In their response to comments on climate change (66 FR 55732, p. 55757), the NRC emphasized the importance of including “climate change in both the geosphere and biosphere performance calculations to ensure that the conceptual model of the environment is consistent with our scientific understanding of anticipated natural events.” Similarly, in their background discussion of the specification of a probability for unlikely FEPs, the NRC stated that “DOE’s performance assessments are required to consider the naturally occurring features, events and processes that could affect the performance of a geologic repository...” Based on these statements, the FEPs associated with the characteristics of the reference biosphere under 10 CFR 63.305(a) are limited to naturally occurring FEPs and exclude those FEPs related to human activities. Likewise, those geological, hydrological and climatological FEPs that the DOE must vary under 10 CFR 63.305(c) are also limited to naturally occurring FEPs.

Therefore, those portions of this FEP that focus on the consequences of human activities on biosphere characteristics are excluded consistent with the requirements of 10 CFR 63.305(c).

6.2.32 Biosphere Transport (FEP 2.3.13.02.00)

FEP Description:

Radionuclides contained in sediments and surface water bodies and in the gaseous phase may be transferred to the biosphere by a variety of processes. Once in the biosphere, radionuclides may be transported and transferred through and between different compartments of the biosphere. Time-dependent chemical environments in the biosphere may promote or retard the transport and transfer processes, and consequently control exposure to the human population.

*Screening Decision
And Regulatory Basis:*

Include radionuclide transport and transfer processes, including alterations during transport, through and between biosphere compartments in accordance with the requirements of 10 CFR 63.305(a).

Exclude radionuclide transport in surface water bodies under current climatic conditions on the basis of inconsistency with the requirement in 10 CFR 63.305(a). Include radionuclide transport in surface water bodies under future climatic conditions on the basis of consistency with the requirement in 10 CFR 63.305(c).

Screening Argument:

Those portions of this FEP that consider both transport processes and alterations during transport in the biosphere under current and future climatic conditions are included in accordance with 10 CFR 63.305(a) and (c).

The region around Yucca Mountain lacks permanent surface water bodies. Section 7.1 of *Yucca Mountain Site Description* (CRWMS M&O 2000b) and Figure 2–2 of *Information and Analyses to Support Selection of Critical Groups and Reference Biospheres for Yucca Mountain Exposure Scenarios* (LaPlante and Poor 1997) indicate there are no perennial lakes and rivers within approximately 40 km of the location of Yucca Mountain. As a result, that part of this FEP that deals with surface water bodies and resulting sediments are excluded on the basis of inconsistency with the requirements of 10 CFR 63.305(a).

Future climate forecasts indicate that the climate will evolve to a cooler and wetter climatic state within the next 10,000 years (USGS 2001, Section 6.6). Monsoon and Intermediate states are predicted to last until 38,000 years A.P. (Sharpe 2002, Table 6-6). Estimates of the effect of this climatic change (DOE 2002b, p. 3-59) indicate that the regional groundwater table could rise between 50 and 130 meters. Given the depth to groundwater shown in Figure 2-2 of *Information and Analyses to Support Selection of Critical Groups and Reference Biospheres for Yucca Mountain Exposure Scenarios* (LaPlante and Poor 1997) and the possible paleo-discharge locations identified in *Simulated Effects of Climate Change on the Death Valley Regional Ground-Water Flow System, Nevada and California* (D’Agnese et al. 1999, p. 6), transport in surface water is included for future climatic conditions consistent 10 CFR 63.305(c).

6.2.33 Human Characteristics (Physiology, Metabolism) (FEP 2.4.01.00.00)

FEP Description:

This category contains FEPs related to human characteristics. These include physiology, metabolism, and variability among individual humans.

*Screening Decision
and Regulatory Basis:*

Include those characteristics of the human adult, as per 10 CFR 63.312(e).

Screening Argument:

10 CFR 63.312(e) specifies that the RMEI is an adult. As a result, consideration is limited to an adult.

6.2.34 Diet and Fluid Intake (FEP 2.4.03.00.00)

FEP Description: This category contains FEPs related to human diet and fluid intake. Consumption of food, water, soil, drugs, etc., will affect human exposure to radionuclides. Other influences include filtration of water, dilution of diet with uncontaminated food, and food preparation techniques.

Screening Decision and Regulatory Basis: Include those dietary characteristics as per the requirements of 10 CFR 63.312(b) and (d).

Screening Argument: 10 CFR 63.312(b) requires consideration of the dietary and living styles of the RMEI, based on the people who reside in the Town of Amargosa Valley, Nevada. In addition, 10 CFR 63.312(d) requires the RMEI to drink 2 liters of water per day from wells drilled into the ground water.

6.2.35 Human Lifestyle (FEP 2.4.04.01.00)

FEP Description: Human lifestyle, including leisure activities, will influence the critical exposure pathways to man.

Screening Decision and Regulatory Basis: Include aspects of human lifestyle including work, leisure activities as per the requirements of 10 CFR 63.312(b).

Screening Argument: 10 CFR 63.312(b) specifies that the living style of the RMEI be based on the people who reside in the Town of Amargosa Valley, Nevada. Therefore those human lifestyle characteristics that are representative of the residents of Amargosa Valley are included.

6.2.36 Dwellings (FEP 2.4.07.00.00)

FEP Description: This category contains FEPs related to human dwellings, and the ways in which dwellings might affect human exposures. Exposure pathways might be influenced by building materials, location, and everyday household activities.

Screening Decision and Regulatory Basis: Include household activities and dwelling characteristics that might influence human exposures, including use of evaporative cooling, as per the requirements of 10 CFR 63.312(b).

Include the location of the RMEI based on the requirements of 10 CFR 63.312(a).

Exclude variations in location of the RMEI based on the regulatory requirements in 10 CFR 63.312(a).

Screening Argument:

Data from *The 1997 "Biosphere" Food Consumption Survey Summary Findings and Technical Documentation* (DOE 1997, Table 2.4.2) indicate that the predominant housing type is a trailer/mobile home and that most residences have swamp coolers. As a result dwelling characteristics that might influence human exposures are included as per the requirements of 10 CFR 63.312(b).

10 CFR 63.312(a) specifies the location of the RMEI relative to the accessible environment and the radionuclide concentration in the plume in the ground water. As a result, only one location is considered while other locations are excluded on the basis of the regulatory requirement.

6.2.37 Wild and Natural Land and Water Use (FEP 2.4.08.00.00)

FEP Description:

This category contains FEPs related to human uses of wild and natural lands (forests, bush, coastlines) and water (lakes, rivers, oceans) that may affect the long-term performance of the repository. Wild and natural land use will be primarily controlled by natural factors (topography, climate, etc.).

*Screening Decision
and Regulatory Basis:*

Include consistent with the requirements of 10 CFR 63.312(b) and 10 CFR 63.305(a).

Screening Argument:

10 CFR 63.312(b) specifies that the RMEI has a diet and living style representative of the people living in the Town of Amargosa Valley, Nevada. Use of wild and natural lands and waters must be consistent with present knowledge of conditions in the region surrounding the Yucca Mountain site in accordance with 10 CFR 63.305(a).

6.2.38 Agricultural Land Use and Irrigation (FEP 2.4.09.01.00)

FEP Description:

Agricultural land use depends on many interrelated factors including climate, geology, topography, human lifestyle and economics. Land use includes traditional crop farming, greenhouses, and hydroponics. Agricultural activities may influence the long-term performance of the repository through contamination of the food chain or alternative exposure pathways. Agricultural activities of concern include irrigation, ploughing, fertilization, crop storage, application of soil conditioners and agricultural chemicals, and fires.

*Screening Decision
and Regulatory Basis:*

Include current agricultural land use practices per the requirements of 10 CFR 63.312(b).

Screening Argument:

10 CFR 63.312(b) specifically requires that the RMEI have a diet and living style that is representative of the people who now reside in the Town of Amargosa Valley, Nevada. Since agricultural activities are being practiced in Amargosa Valley (DOE 2002b, pp. 3-7), this FEP is included.

6.2.39 Animal Farms and Fisheries (FEP 2.4.09.02.00)

FEP Description:

Domestic livestock or fish could become contaminated through the intake of contaminated feed, water, or soil. Such contamination would then enter the food chain.

*Screening Decision
and Regulatory Basis:*

Include consumption of contaminated domestic livestock and fish as per 10 CFR 63.312(b).

Screening Argument:

10 CFR 63.312(b) requires that the diet of the RMEI be representative of the people residing in the Town of Amargosa Valley, Nevada. Dietary survey data (DOE 1997, Section 2.3) indicate that residents consume locally produced domestic live stock and fish that ingest ground water from local wells. Therefore, this FEP is included.

6.2.40 Urban and Industrial Land and Water Use (FEP 2.4.10.00.00)

FEP Description:

This category contains FEPs related to urban and industrial uses of land and water (industry, urban development, earthworks, energy production, etc.) that may affect the long-term performance of the repository. Urban and industrial land use will be controlled by both natural factors (topography, climate, etc.) and human factors (economics, population density, etc.).

*Screening Decision
and Regulatory Basis:*

Include those aspects that are consistent with present knowledge of conditions in the region surrounding the Yucca Mountain site (10 CFR 63.305(a) and are consistent with the living style representative of the people who now reside in the Town of Amargosa Valley, Nevada (10 CFR 63.312(b).

Exclude aspects that deal with changes in existing urban and industrial uses of land and water on the basis of 10 CFR 63.305(b).

Screening Argument:

Urban and industrial land and water use must be consistent with present knowledge of the conditions in the region surrounding the

Yucca Mountain site in accordance with 10 CFR 63.305(a). 10 CFR 63.312(b) specifies that the RMEI have living style representative of the people living in the Town of Amargosa Valley, Nevada.

10 CFR 63.305(b) specifies that the DOE should not project changes in society, therefore this aspect of the FEP is excluded on the basis of the regulation.

6.2.41 Radioactive Decay and In-growth (FEP 3.1.01.01.00)

FEP Description:

Radioactivity is the spontaneous disintegration of an unstable atomic nucleus that results in the emission of subatomic particles. Radioactive isotopes are known as radionuclides. Ingrowth occurs when a parent radionuclide decays to a daughter nuclide so that the population of the daughter nuclide increases. Over a 10,000-year performance period, these processes will produce daughter products that need to be considered in order to adequately evaluate the release and transport of radionuclides to the accessible environment.

Screening Decision and Regulatory Basis:

Include radioactive decay and ingrowth on the basis of 10 CFR 63.305(a).

Screening Argument:

10 CFR 63.305(a) requires consideration of processes that are consistent with current knowledge of the conditions of the region around Yucca Mountain. Since radioactive decay and in-growth is a process that is consistent with current knowledge, this FEP is included on the basis of the regulation.

6.2.42 Drinking Water, Foodstuffs and Drugs, Contaminant Concentrations in (FEP 3.3.01.00.00)

FEP Description:

This category contains FEPs related to human exposure to contaminants as a result of ingesting foodstuffs, water, or drugs.

Screening Decision and Regulatory Basis:

Include ingestion of locally grown foods and consumption of local groundwater consistent with the requirements of 10 CFR 63.312(b).

Screening Argument:

10 CFR 63.312(b) requires that the diet of the RMEI be representative of the people residing in the Town of Amargosa Valley, Nevada. Dietary survey data (DOE 1997, Section 2.3) indicate that residents consume locally grown foods and groundwater. Therefore, this FEP is included.

6.2.43 Plant Uptake (FEP 3.3.02.01.00)

FEP Description: Uptake of contaminants by plants could affect the long-term performance of the disposal system. Some contaminants escaping from the repository are expected to eventually be able to reach natural outfalls (e.g., Franklin Lake Playa), where plant uptake would be possible. Particulate deposition onto plant surfaces is also possible. These plants may be used as feed for livestock and/or consumed directly by humans.

Screening Decision and Regulatory Basis: Include plant uptake of radionuclides, deposition of radionuclides on plant surfaces, and subsequent ingestion by livestock and humans as per the requirements of 10 CFR 63.312(b).

Screening Argument: 10 CFR 63.312(a) specifies the location of the RMEI relative to the accessible environment and the plume of radionuclide contamination in groundwater. In addition, 10 CFR 63.312(b) requires that the diet of the RMEI be representative of the people residing in the Town of Amargosa Valley, Nevada. A dietary survey of the region around Yucca Mountain (DOE 1997, Section 2.3) indicates that the residents of Amargosa Valley consume locally grown crops from home gardens and that source of water for these gardens is water from a local ground source. Therefore, plant uptake of radionuclides is included.

6.2.44 Animal Uptake (FEP 3.3.02.02.00)

FEP Description: Livestock and fish may accumulate radionuclides as a result of ingestion of water, feed and soil/sediment and inhalation of aerosols and particulates. Depending on the livestock, they may be used for human consumption directly, or their produce (milk, eggs, etc.) may be consumed.

Screening Decision and Regulatory Basis: Include accumulation of radionuclides in livestock and fish and subsequent transfer to man via the ingestion pathway as per the requirements of 10 CFR 63.312(b).

Screening Argument: 10 CFR 63.312(b) requires that the diet and living style of the RMEI be representative of the people who now reside in the Town of Amargosa Valley, Nevada. A dietary survey (DOE 1997, Section 2.3) indicates that the residents of Amargosa Valley do consume locally grown livestock and fish, therefore this FEP is included.

6.2.45 Bioaccumulation (FEP 3.3.02.03.00)

FEP Description: Contaminants may accumulate in different organisms, including members of the critical group, affecting impacts. Bioconcentration and biomagnification are related processes.

Screening Decision and Regulatory Basis: Include accumulation (i.e. bioaccumulation, bioconcentration, and biomagnification) of radionuclides in different organisms consistent with the requirements of 10 CFR 63.305(a).

Screening Argument: Bioaccumulation, bioconcentration, and biomagnification are processes that may occur and may influence the movement of radionuclides through the biosphere to man and are therefore included per the requirements of 10 CFR 63.305(a).

6.2.46 Contaminated Non-Food Products and Exposure (FEP 3.3.03.01.00)

FEP Description: Contaminants may be concentrated in various products: clothing (e.g., hides, leather, linen, wool); furniture (e.g., wood, metal); building materials (e.g., stone, clay for bricks, wood, dung); fuel (e.g., peat), tobacco, pets.

Screening Decision and Regulatory Basis: Include the use of contaminated non-food products by the RMEI consistent with the requirement of 10 CFR 63.312(b) and (c).

Screening Argument: 10 CFR 63.312(b) specifies that the RMEI has a living style representative of the people now residing in the Town of Amargosa Valley, Nevada. 10 CFR 63.312(c) specifies that the RMEI uses water from a well at a rate of 3000 acre-feet per year. This FEP is, therefore, included on the basis of consistency with these requirements.

6.2.47 Ingestion (FEP 3.3.04.01.00)

FEP Description: Ingestion is human exposure to repository-derived radionuclides through eating contaminated foodstuffs or drinking contaminated water.

Screening Decision and Regulatory Basis: Include the ingestion of repository-derived radionuclides through consumption of contaminated foodstuffs or drinking contaminated water as per the requirements of 10 CFR 63.312(b).

Screening Argument: 10 CFR 63.312(b) requires that the diet of the RMEI be representative of the people residing in the Town of Amargosa Valley, Nevada. Dietary survey data (DOE 1997, Section 2.3)

indicate that consumption of groundwater and locally grown livestock and fish does occur. Therefore, this FEP is included.

6.2.48 Inhalation (FEP 3.3.04.02.00)

FEP Description: Two inhalation pathways are likely. The first is inhalation of gases and vapors emanating directly from the ground after transport through the far-field. The second is inhalation of suspended, contaminated particulate matter (e.g., daughter products of radon, dust, smoke, pollen, and soil particles).

Screening Decision and Regulatory Basis: Include inhalation of gases/vapor and suspended, contaminated particulate matter as per the requirements of 10 CFR 63.305(a).

Screening Argument: 10 CFR 63.305(a) requires consideration of features, events and processes that are consistent with present knowledge of conditions around the Yucca Mountain site. These FEPs are processes by which the RMEI may be exposed and are therefore included based on 10 CFR 63.305(a).

6.2.49 External Exposure (FEP 3.3.04.03.00)

FEP Description: External exposure is human exposure to repository-derived radionuclides by contact, use, or exposure to contaminated materials. The mode is typically through dermal sorption.

Screening Decision and Regulatory Basis: Include external exposure to radionuclides per 10 CFR 63.312(b).

Screening Argument: External exposure to radionuclides through the use of, contact with or exposure to contaminated materials are processes that may lead to the RMEI being exposed depending upon lifestyle. Therefore, this FEP is included consistent with the 10 CFR 63.312(b).

6.2.50 Radiation Doses (FEP 3.3.05.01.00)

FEP Description: The radiation dose is calculated from exposure rates (external, inhalation, and ingestion) and dose conversion factors. The latter are based upon radiation type, human metabolism, metabolism of the element of concern in the human body, duration of exposure.

Screening Decision and Regulatory Basis: Include radiation dose as per the requirement of 10 CFR 63.311.

Screening Argument: 10 CFR 63.311 establishes an annual dose limit for the RMEI. Therefore, this FEP is included.

6.2.51 Radiological Toxicity/Effects (FEP 3.3.06.00.00)

FEP Description: This category contains FEPs related to the estimation of human health effects resulting from radiation doses.

Screening Decision and Regulatory Basis: Exclude radiotoxicity on the basis of the requirement of 10 CFR 63.311.

Screening Argument: Section 311 of 10 CFR 63 requires the calculation of a radiation dose to the RMEI, and does not require the calculation of health effects. Therefore, this FEP is excluded on the basis of regulation.

6.2.52 Sensitization to Radiation (FEP 3.3.06.02.00)

FEP Description: Human and other organisms may become sensitized to radiation exposure so that its effects are more severe.

Screening Decision and Regulatory Basis: Exclude the increase in biological effects of radiation exposure due to sensitivity on the basis of the requirement of 10 CFR 63.305(b).

Screening Argument: 10 CFR 63.305(b) states that the DOE should not project changes in human biology. Therefore, this FEP is excluded on the basis of regulation.

6.2.53 Non-Radiological Toxicity/Effects (FEP 3.3.07.00.00)

FEP Description: This category contains FEPs related to the estimation of human health effects resulting from the non-radiological toxicity of the waste.

Screening Decision and Regulatory Basis: Exclude the estimation of human health effects resulting from the non-radiological toxicity of the waste on the basis of the requirement of 10 CFR 63.311.

Screening Argument: Section 311 of 10 CFR Part 63 requires the calculation of a radiation dose to the RMEI, and does not require the estimation of health effects resulting from the non-radiological toxicity of the waste.

6.2.54 Radon and Radon Daughter Exposure (FEP 3.3.08.00.00)

FEP Description: This category contains FEPs related to human exposure to radon and radon decay products. Ra-226 occurs in nuclear fuel waste and it gives rise to radon (Rn-222) gas, the radioactive daughters of which can be harmful to humans and animals upon inhalation.

*Screening Decision
and Regulatory Basis:*

Include as per the requirements of 10 CFR 63.305(a).

Screening Argument:

Human exposure to radon and radon decay products can occur via inhalation and external exposure. 10 CFR 63.305(a) requires consideration of those processes, consistent with the present knowledge of conditions. This is a FEP by which humans can be exposed and is therefore included.

7. CONCLUSIONS

Of the 54 primary FEPs identified in Table 1 of this report, 36 FEPs are screened as applicable, and should be considered in the development of a biosphere model. The FEPs that should be considered are identified in Table 2. The status of and/or changes to the referenced documents may affect the conclusions in this document. Any changes to this SAR that may occur as a result of changes to the referenced documents will be reflected in subsequent revisions.

Table 2. Biosphere-related Features, Events, and Processes to be Considered in the Biosphere Model

FEP NAME	YMP FEP DATABASE NUMBER
Ashfall	1.2.04.07.00
Erosion/denudation	1.2.07.01.00
Deposition	1.2.07.02.00
Climate change, global	1.3.01.00.00
Water table rise	1.3.07.02.00
Wells	1.4.07.02.00
Capillary rise	2.2.07.03.00
Distribution and release of nuclides from the geosphere	2.208.11.00
Soil type	2.3.02.01.00
Radionuclide accumulation in soils	2.3.02.02.00
Soil and sediment transport	2.3.02.03.00
Surface water transport and mixing	2.3.04.01.00
Precipitation	2.3.11.01.00
Surface runoff and flooding	2.3.11.02.00
Groundwater discharge to the surface	2.3.11.04.00
Biosphere characteristics	2.3.13.01.00
Biosphere transport	2.3.13.02.00
Human characteristics (physiology, metabolism)	2.4.01.00.00
Diet and fluid intake	2.4.03.00.00
Human lifestyle	2.4.04.01.00
Dwellings	2.4.07.00.00
Wild and Natural Land and Water Use	2.4.08.00.00

Table 2. Biosphere-related Features, Events, and Processes to be Considered in the Biosphere Model

FEP NAME	YMP FEP DATABASE NUMBER
Agricultural land use and irrigation	2.4.09.01.00
Animal farms and fisheries	2.4.09.02.00
Urban and Industrial Land and Water Use	2.4.10.00.00
Radioactive decay and in-growth	3.1.01.01.00
Drinking water, foodstuffs and drugs, contaminant concentrations in	3.3.01.00.00
Plant uptake	3.3.02.01.00
Animal uptake	3.3.02.02.00
Bioaccumulation	3.3.02.03.00
Contaminated Non-Food Products and Exposure	3.3.03.01.00
Ingestion	3.3.04.01.00
Inhalation	3.3.04.02.00
External exposure	3.3.04.03.00
Radiation doses	3.3.05.01.00
Radon and Radon Daughter Exposure	.3.3.08.00.00

8. INPUTS AND REFERENCES

8.1 REFERENCES CITED

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