Risk Insights Baseline Report: A Basis for Risk-Informed Decision Making in the High-Level Waste Repository Safety Program

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Presentation Outline

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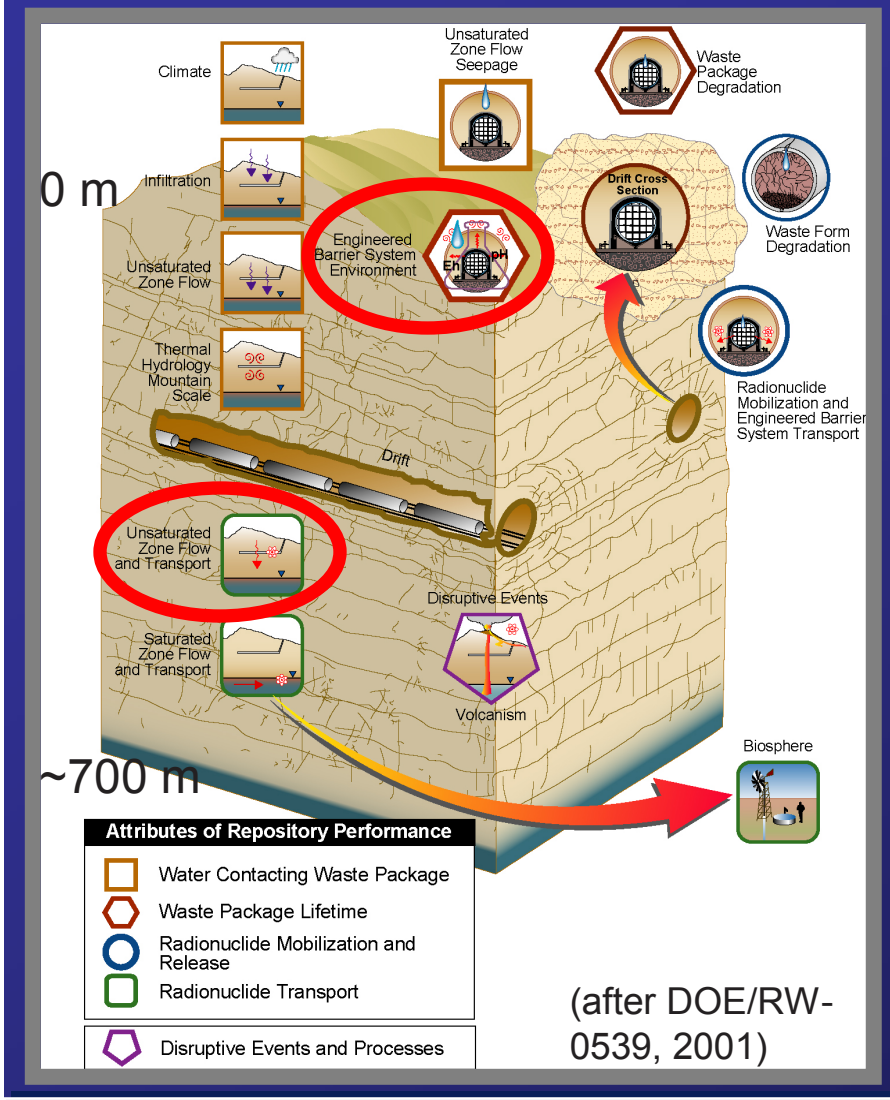
- Application of risk insights
  - Localized corrosion of waste package
  - Unsaturated zone radionuclide transport
- Conclusions
- Acknowledgements

Introduction



(after DOE/RW-0539, 2001)

- **The U.S. Department of Energy (DOE) recommended Yucca Mountain, Nevada as the site for geologic disposal**
- **The U.S. Nuclear Regulatory Commission (NRC) published risk-informed, performance-based licensing criteria for disposal in a potential repository at Yucca Mountain, Nevada**

Introduction – NRC program

- Performance assessment is the basis for determining compliance with post-closure safety regulatory requirements
- NRC has conducted independent performance assessments for over 15 years
- NRC's understanding of post-closure system performance captured in the Risk Insights Baseline Report
- NRC conducts pre-licensing interactions with DOE to facilitate a timely review of a license application
- A risk-informed and performance-based regulation and review plan; and independent risk insights are the basis for the NRC pre-licensing interactions and for the NRC review of the DOE license application

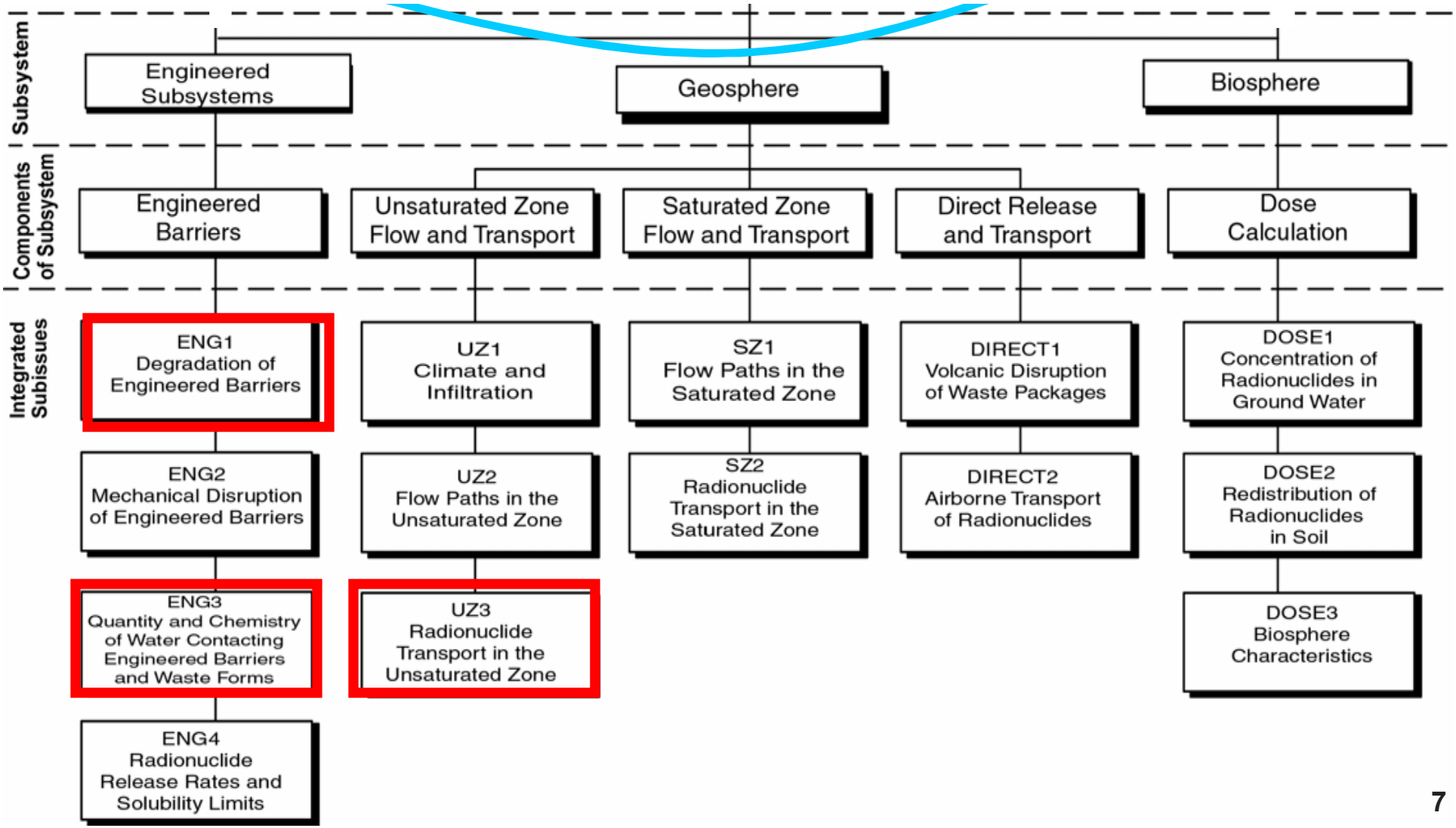
Using Risk Information to Review a Performance Assessment

- Framework for review specified in Yucca Mountain Review Plan
- 4 major aspects of post-closure review
  - Multiple barriers (description, technical basis, and consistency with performance assessment)
  - Scenario analysis (identification and screening of features, events and processes), including the development and probability of scenarios
  - Model abstractions (model integration, sufficiency of data and parameters, data uncertainty and propagation, model uncertainty, and model support)
  - Demonstration of compliance with standards

NRC's Risk-Informed Logic for Determining Staff's Focus

NRC Relative Significance	Identified by DOE as Barrier	Level of Focus in NRC Review
High	Yes	High
High	No	Moderate
Low	Yes	High
Low	No	Low

Components of Performance Assessment Review in Yucca Mountain Review Plan



Risk Insights Baseline Report

- Clarifies application of risk terminology in NRC high-level waste (HLW) program
- Documents system-level and detailed risk insights
- Describes quantitative analyses supporting risk insights
- Documents associated uncertainties
- Describes application of risk insights in HLW program (e.g., issue resolution and review of license application)

Risk Insights Baseline Report

- Insight significance rated based on potential effect on
  - Integrity of waste package
  - Release of radionuclides
  - Radionuclide transport thru geosphere and biosphere
- Relative significance (high, medium, and low)
  - High associated with processes that can affect large number of waste packages, have significant effects on radionuclide release or transport
  - Medium associated with lesser effect on waste packages, radionuclide release or transport
  - Low associated with no or negligible effect

Risk Insights Baseline Report

- Application of risk insights – two examples
  - Localized corrosion of waste package
  - Unsaturated zone radionuclide transport

Example	Process	Significance
Localized corrosion of waste package	Chemistry of Seepage Water	High
Localized corrosion of waste package	Persistence of a Passive Film	High
Unsaturated zone radionuclide transport	Matrix Diffusion in the Unsaturated Zone	Medium

Schematic of Two Factors Affecting Localized Corrosion

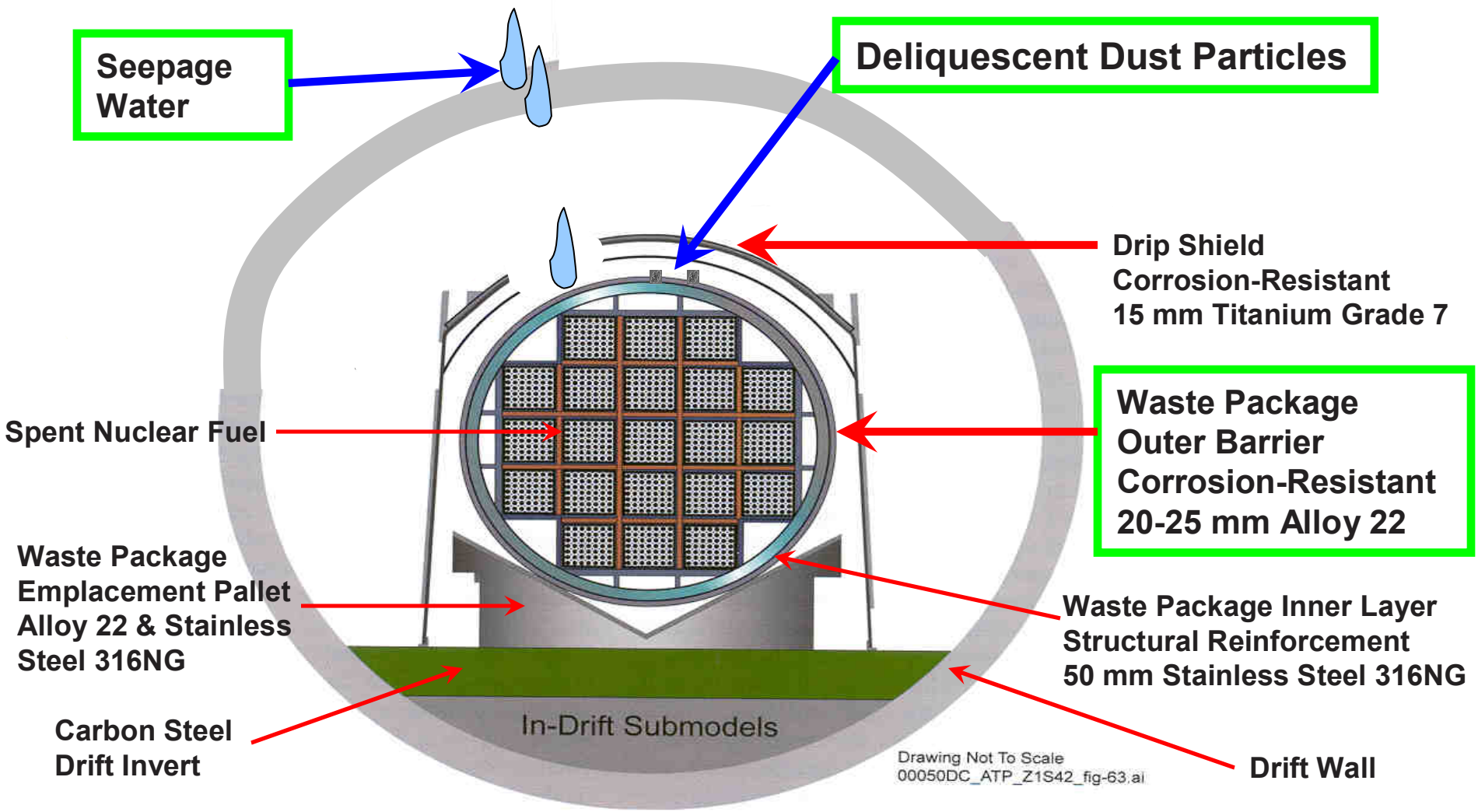


Figure 4-74. Emplacement Drift Cross Section Showing the Processes Considered in the Evolution of the Physical and Chemical Environment, and in the Transport of Radionuclides, within the Emplacement Drifts

Source: Modified from CRWMS M&O 1998g, Chapter 4, Figure 4-1

(after DOE/RW-0539, 2001)

Application of Risk Insights – Localized Corrosion of Waste Package

- Previous DOE approach included model for localized corrosion (seepage and deliquescence-induced)

- NRC reviewed, in detail, DOE's model abstraction
  - Model integration
  - Sufficiency of data and parameters
  - Data uncertainty and propagation
  - Model uncertainty
  - Model support

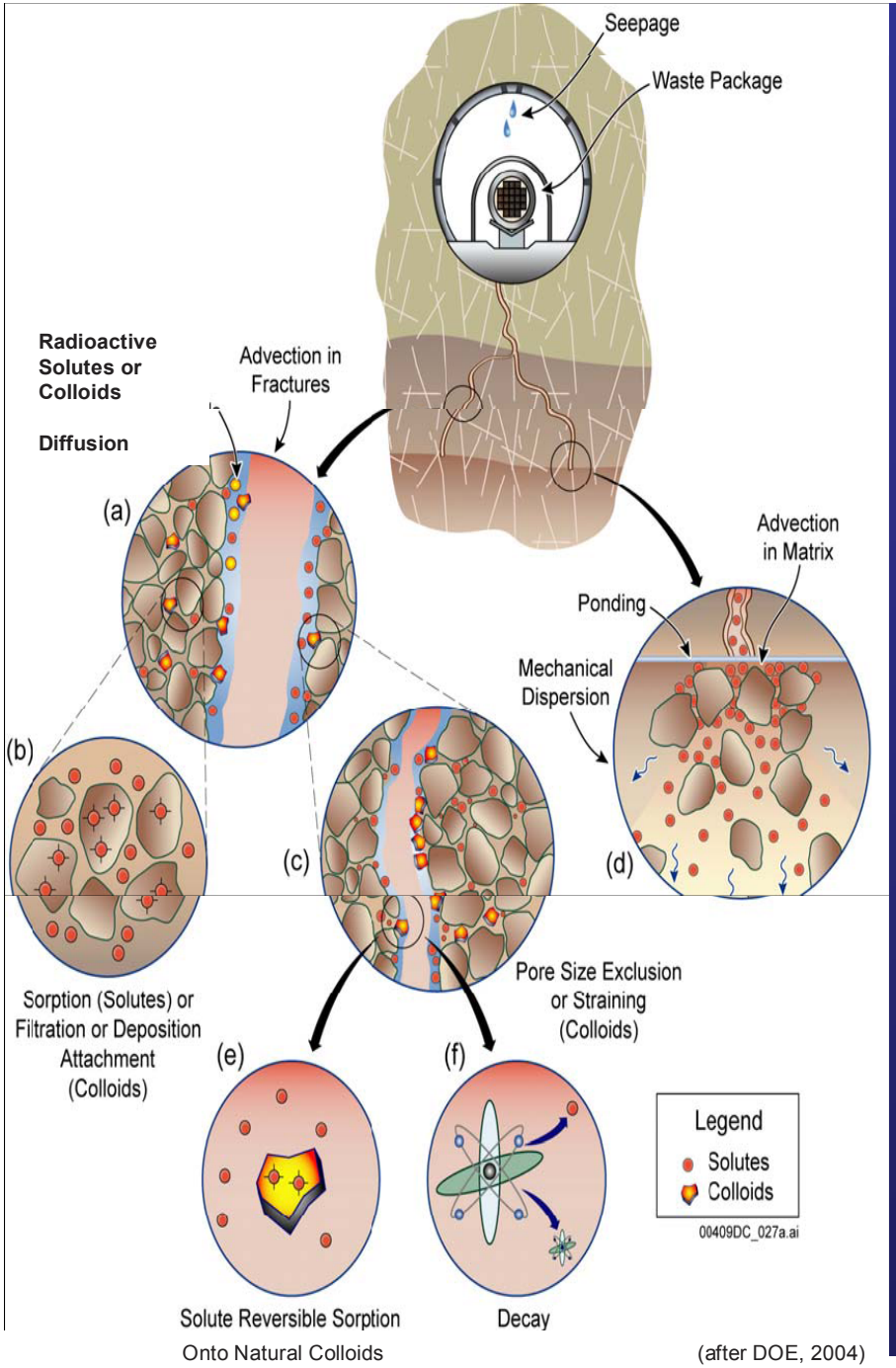
Application of Risk Insights – Localized Corrosion of Waste Package

- DOE intends to screen out dust deliquescence-induced corrosion by addressing 5 questions
  - Can brines form?
  - Will they persist?
  - If persistent, will they be corrosive?
  - If corrosive brines form would localized corrosion be initiated?
  - Would penetration of the outer barrier occur if localized corrosion began?
- NRC has shifted review focus to basis of DOE's screening decision

Application of Risk Insights – Unsaturated Zone Radionuclide Transport

Radionuclide	Attributes of Waste Isolation		
	Unsaturated Zone	Saturated Zone - Tuff	Saturated Zone - Alluvium
Americium-241	DDD	DDD	DDD
Plutonium-240	DDD	DD	DDD
Plutonium-239	DDD	DDD	DDD
Technetium-99	D	D	D
Uranium-234	DDD	D	DDD
Nickel-59	DDD	D	DDD
Neptunium-237	DDD	D	DDD
Niobium-94	D	DD	DDD
Cesium-135	DDD	DDD	DDD
Selenium-79	DD	D	DD
Uranium-238	DDD	D	DDD
Curium-246	D	DD	DDD
Iodine-129	D	D	D
Thorium-230	DDD	DD	DDD
Radium-226	DDD	DD	DDD
Lead-210	DDD	DD	DDD

D denotes delay time of at least 10,000 years (DDD); 1000 years (DD); and 100 years (D).



(after DOE, 2004)

Schematic of Processes Affecting Radionuclide Transport

Unsaturated Zone Transport

- **Retardation in DOE's unsaturated zone model is dominant in fractured rock (fracture/matrix interaction is important)**
- **Retardation in NRC's conceptualization of transport in the unsaturated zone is dominant in porous rock**

Application of Risk Insights – Unsaturated Zone Radionuclide Transport

- NRC's review has focused on DOE's abstraction of matrix diffusion
  - As part of issue resolution NRC requested that DOE provide independent lines of evidence to support DOE's use of the active-fracture model
- DOE believes its current approach is conservative and may increase retardation
- If DOE increases the capability of the unsaturated zone to retard radionculides, NRC may increase scrutiny of DOE's model and its technical basis

Conclusions

- NRC has developed risk-informed and performance-based regulations, review guidance, and independent risk insights
- NRC has developed a logic for reviewing a license application that considers DOE's licensing case and NRC's independent risk insghts
- NRC is implementing this risk-informed and performance-based framework in its review activities

Acknowledgements

- The NRC staff views expressed herein are preliminary and do not constitute a final judgment or determination of the matters addressed or of the acceptability of a license application for a geologic repository at Yucca Mountain.

- Reviews by Chris Grossman and Andy Campbell clarified the presentation