Repository Safety Strategy – Implementation

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Implementing Strategy to Complete Safety Case for SR

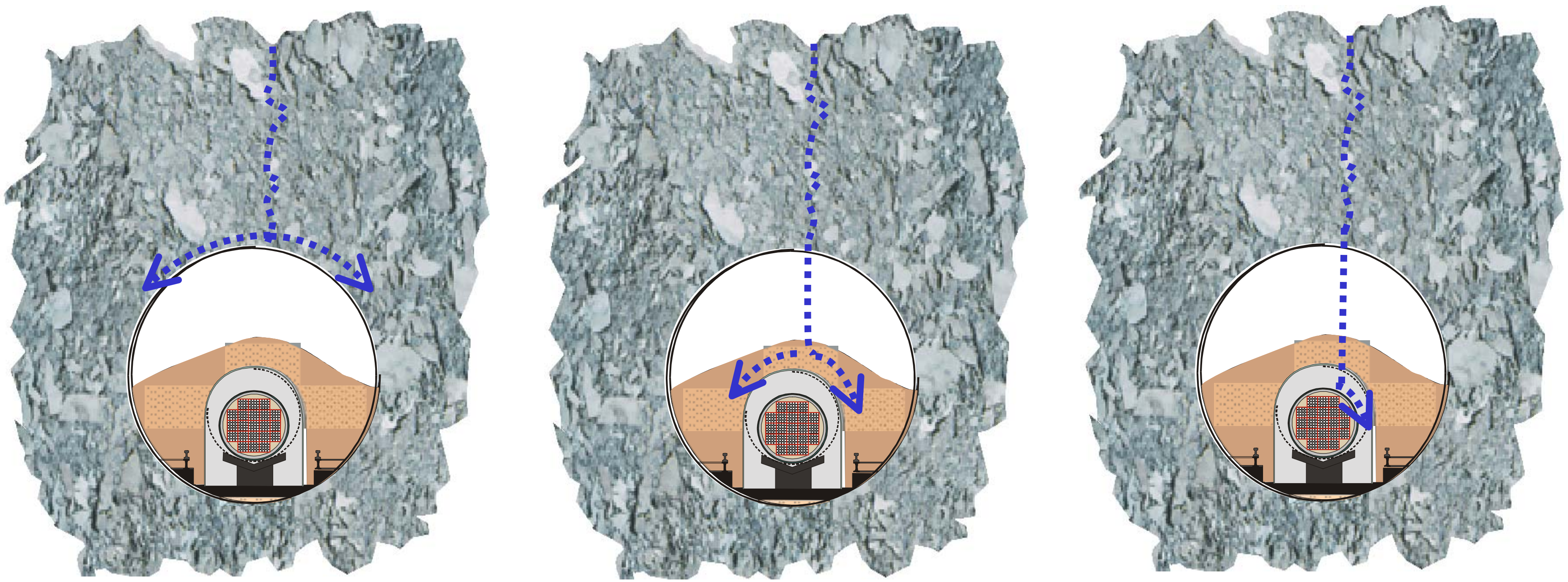
- **Since VA, we have been following the plan in Volume 4 (RSS Rev 2) for developing the Safety Case**
- **Implementation started from 19 principal factors for VA system concept**
- **Steps in the implementation**
  - **Evaluation of new data and design enhancements**
  - **Update set of factors**
  - **Preliminary TSPA and Barriers Importance Assessment to identify principal factors**
  - **Prioritize work to complete Safety Case**

SR Design Enhancements Affecting Postclosure Performance

- More robust waste package
- Redundant drip shield to provide defense-in-depth
- Backfill to protect waste package and drip shield
- Improved thermal design

Defense-in-Depth for Water Diversion

Diversion by Capillary Barrier | **Diversion by Drip Shield** | **Diversion by Waste Package**



Update Factors for Nominal Scenario

Start From Principal Factors of VA System Design

Key Attributes of Repository System	Principal Factors of VA System Design
Limited Water Contacting Waste Package	Precipitation and infiltration into mountain
	Percolation to depth
	Seepage into drifts
	Effects of heat and excavation on flow
Long Waste Package Lifetime	Dripping on waste package
	T, RH at waste package
	Chemistry on waste package
	Integrity of WP outer barrier
	Integrity of WP inner barrier
Low Rate Of Release of Radionuclides From Breached Waste Packages	Seepage into waste package
	Integrity of SNF cladding
	Dissolution of SNF and glass waste forms
	Neptunium solubility
	Formation of radionuclide-bearing colloids
	Transport through and out of EBS
Radionuclide Concentration Reduction During Transport from the Waste Packages	Transport though UZ
	SZ flow and transport
	Dilution from pumping
	Biosphere transport and uptake

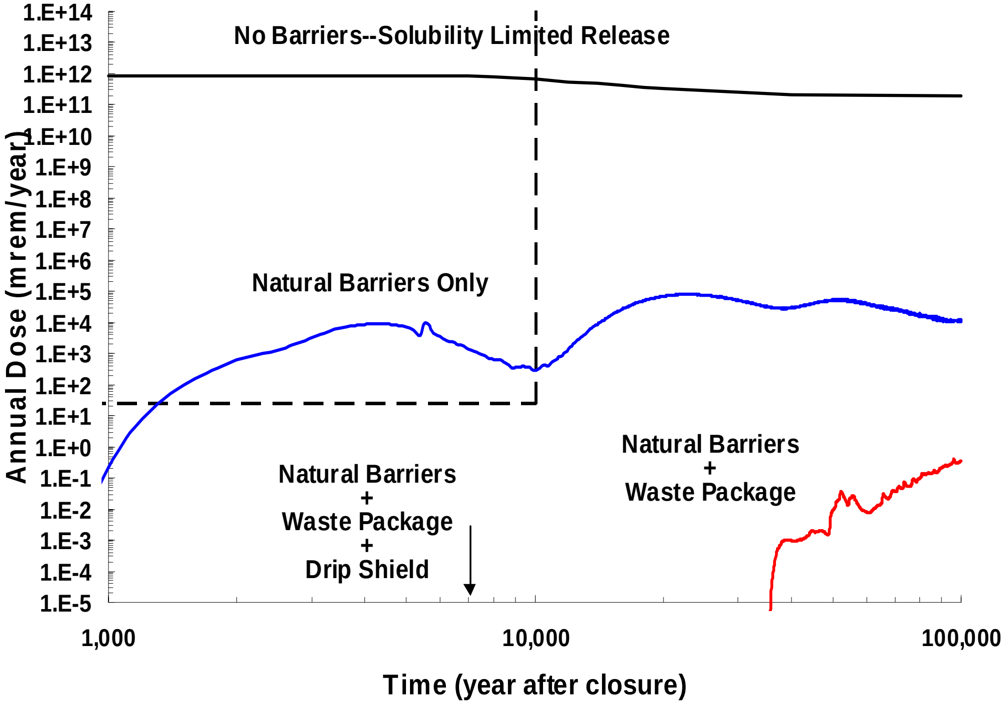
Augment List to Address New Data and Design Enhancements

Key Attributes of System	Factors for Enhanced System Design
Water Contacting Waste Package	Climate
	Net infiltration into the mountain
	UZ flow above repository
	Seepage into drifts
	Coupled processes - effects on UZ flow
	Coupled processes - effects on seepage
	Environments on drip shield
	Performance of drip shield
Waste Package Lifetime	Environments on waste package
	Performance of waste package barriers
Radionuclide Mobilization and Release from the Engineered Barrier System	Environments within waste package
	CSNF waste form performance
	DSNF, Navy fuel, Pu disposition waste form performance
	DHLW glass waste form performance
	Solubility limits of dissolved radionuclides
	Colloid-associated radionuclide concentrations
	In-package radionuclide transport
	Transport through the drift invert
Transport Away from the Engineered Barrier System	Advective pathways in UZ
	Retardation of radionuclide migration in UZ
	Colloid-facilitated transport in UZ
	Coupled processes--effects on UZ transport
	Advective pathways in SZ
	Retardation of radionuclide migration in SZ
	Colloid-facilitated transport in SZ
	Dilution of radionuclide concentration
	Biosphere transport and uptake

Goal--Prioritize the Factors

- Conducted workshops to prioritize factors
  - Participants included scientists, engineers, Performance Assessment staff, regulatory personnel
  - Started from preliminary TSPA and Barrier Importance Analyses
  - Considered model uncertainties and limitations of preliminary analyses
  - Assessed current and needed confidence to determine factors needed for adequate safety case
- Objective was to focus work on the most important factors and adequacy of information for the safety case for SR and LA

Preliminary Analyses of Enhanced Design

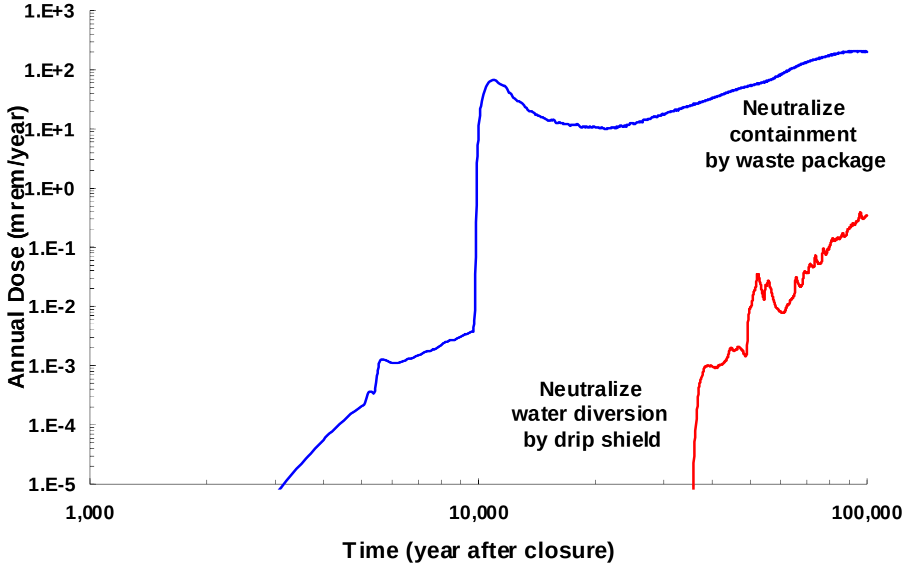


- **Natural barriers effective--reduce estimated dose rate by 8 orders of magnitude**
- **Remaining dose rate due to small number of relatively mobile radionuclides (<0.004% of total)**
- **Effective waste package and drip shield are utilized to address this small residual**
- **System utilizes multiple natural and engineered barriers to ensure postclosure safety**

Barriers Importance Assessment

- **Approach used "neutralization" analyses – specialized sensitivity studies in which an effect is omitted from the calculation to determine its importance to that calculation**
- **Neutralizations do not give expected performance, but are only used to give insight**
- **Considered both nominal performance and unanticipated early failure of waste package to gain insight**

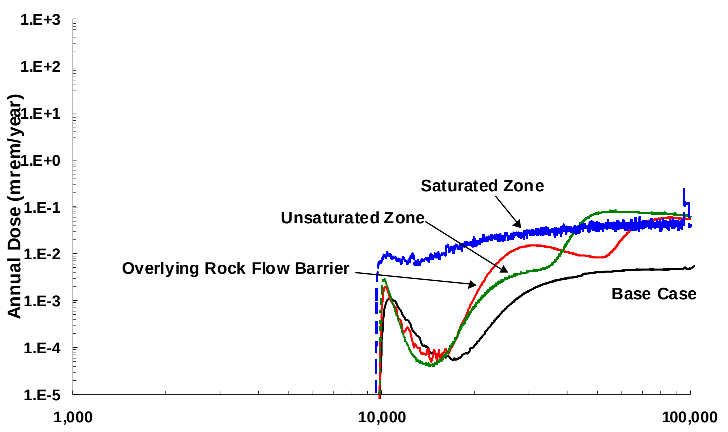
Preliminary Barriers Importance Assessment



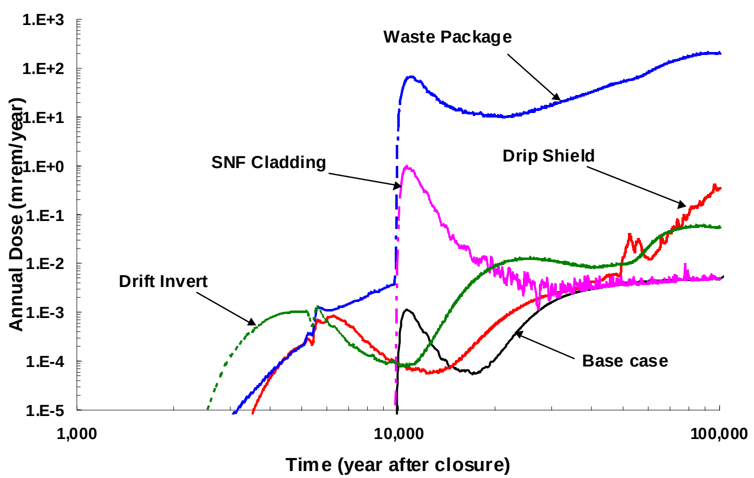
- Base case gave zero release for 100,000 years
- Neutralizations of all but two barriers also gave zero release
  – Barriers unimportant or are backed up by other barriers
  – Compliance may not be sensitive to unresolved issues for these barriers
- Only waste package and drip shield neutralizations gave any contribution for 100,000 years
  – In waste package neutralization, diffusion controls until failure of first drip shield at about 10,000 years
  – Results do not indicate expected performance but do suggest uncertainties in waste package performance are important

Analyses Repeated for Juvenile WP Failure Scenario

Neutralizations of Natural Barriers



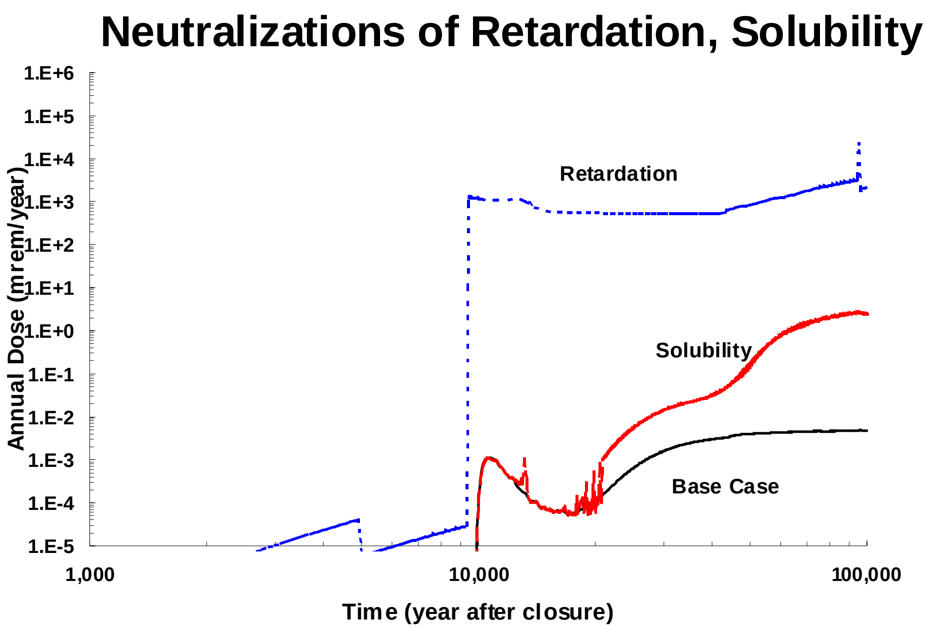
Neutralizations of Engineered Barriers



- Base case began to give release at about 10,000 years (after first drip shield fails)
- No other releases occurred for 100,000 years
- Neutralization of each natural barrier gave minor changes from base case--barriers redundant
- Neutralization of engineered barriers
  - Waste package neutralization gave largest change
  - Change for cladding neutralization of less importance
  - Other changes very minor

Juvenile WP Failure Scenario

(Continued)



- **Although retardation and solubility contributed little for nominal case (radionuclides remain in waste package), they were important after waste packages fail**
- **Retardation was important under all conditions**
- **Solubility was less important, but consideration is still warranted**

Results of Prioritization Workshops

- **Assessed current and needed confidence**
- **Concluded analyses suggest adequate margin; however, appear to rely almost entirely on waste package and drip shield**
- **Concluded confidence would not be adequate for SR unless natural systems could be demonstrated to contribute significantly**
- **Careful review of analyses concluded seepage, retardation, and dilution are also important factors**

Prioritization of Factors for Nominal Scenario

Factors for Enhanced System Design
Climate
Infiltration
UZ flow above repository
Seepage into drifts
Coupled processes - effects on UZ flow
Coupled processes - effects on seepage
Environments on drip shield
Performance of drip shield
Environments on waste package
Performance of waste package barriers
Environments within waste package
CSNF waste form performance
DSNF, Navy fuel, Pu disposition waste form performance
HLW glass waste form performance
Radionuclide solubility limits
Colloid-associated radionuclide concentrations
In-package radionuclide transport
EBS radionuclide migration—transport through invert
UZ flow and transport—advective pathways
Retardation of radionuclide migration in UZ
UZ flow and transport—colloid-facilitated transport
Coupled processes--effects on UZ transport
SZ flow and transport—advective pathways
Retardation of radionuclide migration in SZ
SZ transport--colloid-facilitated transport
Dilution of radionuclide concentrations in UZ and SZ
Biosphere transport and uptake

Principal Factors
Seepage into drifts
Solubility limits of dissolved radionuclides
Dilution of radionuclide concentrations
Retardation of radionuclide migration in UZ
Retardation of radionuclide migration in SZ
Performance of waste package barriers
Performance of drip shield

Other Factors
Climate
Net infiltration into the mountain
UZ flow above repository
Coupled processes - effects on UZ flow
Coupled processes - effects on seepage
Environments on drip shield
Environments on waste package
Environments within waste package
CSNF waste form performance
DSNF, Navy fuel, Pu disposition waste form performance
DHLW glass waste performance
Colloid-associated radionuclide concentrations
In-package radionuclide transport
Transport through the drift invert
Advective pathways in the UZ
Colloid-facilitated transport in the UZ
Coupled processes--effects on UZ transport
Advective pathways in the SZ
Colloid-facilitated transport in the SZ
Biosphere transport and uptake

Using the Factors to Prioritize the Remaining Technical Work

- **Testing and analyses focusing primarily on principal factors and sensitivity analyses to examine potential simplifications in non-principal factors**
- **Addressing particular opportunities for enhanced performance**
  - **Seepage threshold**
  - **Cladding performance**
  - **Canister performance**
- **Work scope is reflected in the plans for the Process Model Reports and the associated Analysis and Model Reports**

Other Needs for Safety Case

- Complete screening of FEPs – confirm identification of principal factors
- Complete model development for principal factors and analyses to support simplification of non-principal factors
- Incorporate parameter and model uncertainty into TSPA
- Complete representation of disruptive events – igneous activity and human intrusion – and identify principal factors for them
- Complete Performance Confirmation Plan

Continuing Development of Strategy

- **Will update strategy after initial analyses for SR to incorporate parameter and model uncertainty and screening of FEPs**
- **Will finalize principal factors of SR Safety Case**
- **Will finalize areas where simplification would be appropriate for LA Safety Case**
- **Additional development possible as result of design evolution and performance confirmation**