U.S. Department of Energy
Office of Civilian Radioactive Waste Management

Scope/Content/Summary of SSPA Volume 1 - Scientific Basis and Analyses

Presented to:
Nuclear Waste Technical Review Board

Presented by:
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YUCCA MOUNTAIN PROJECT

Scope of SSPA Volume 1

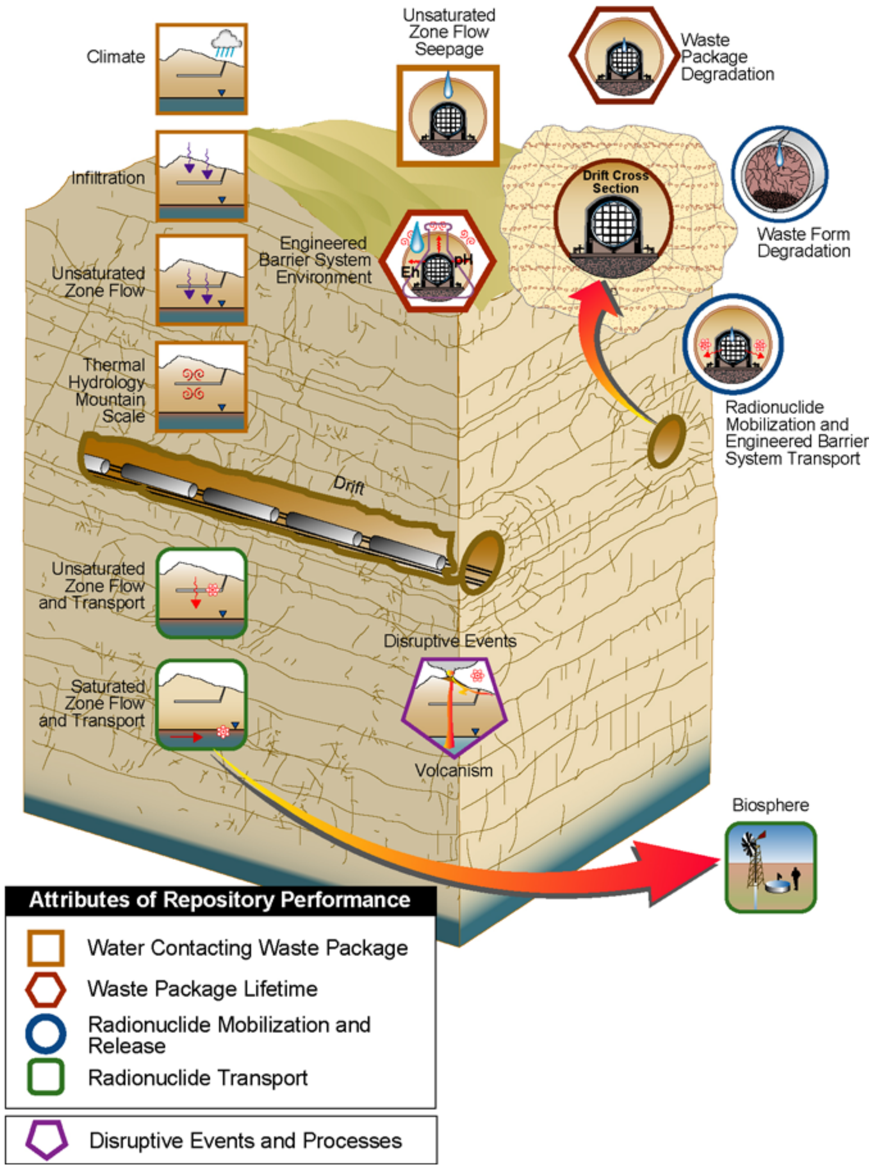
- Volume 1 Covers the major process expected to occur at Yucca Mountain and supplements the information described in Analyses and Model Reports and Process Model Reports
- Subjects are organized in a manner similar to the organization found in the Yucca Mountain Science and Engineering Report
- Volume 1 focuses on the technical work within each process model area, encompassing uncertainty quantification, updated scientific bases, and analyses of a range of operating modes

Scope
(Continued)
Three General Types of Information

- **Unquantified Uncertainties Analysis**
  - Specific uncertainties that were not treated explicity in the AMRs and PMRs supporting the S&ER have been quantified including parameter bounds, conceptual models, assumptions, and in some cases input parameters consisting of statistically biased or skewed distributions
- **Updates in Scientific Information**
  - This includes new experimental results, new conceptual models, new analytical approaches, and the identification and discussion of multiple lines of evidence
- **Thermal Operating Mode Analyses**
  - Includes process level information regarding thermal dependencies; how the process responds to a range of thermal inputs and the impacts on uncertainty in process level results

Scope
(Continued)

- **Sections 3-14 include a summary of the conceptual basis for models used in the S&ER**
- **Specific content and level of detail of each section varies depending on:**
  - **Extent of the analyses performed**
  - **Amount of new information and data that has been generated since the publication of the S&ER and supporting documents**
  - **Amount of information necessary required to evaluate the range of thermal operating modes**
- **Each section contains a summary of information and recommendations for use in Volume 2 if appropriate**



Climate
Infiltration
Unsaturated Zone Flow
Thermal Hydrology Mountain Scale
Unsaturated Zone Flow Seepage
Engineered Barrier System Environment
Eh
pH
Waste Package Degradation
Drift Cross Section
Waste Form Degradation
Radionuclide Mobilization and Engineered Barrier System Transport
Drift
Unsaturated Zone Flow and Transport
Saturated Zone Flow and Transport
Disruptive Events
Volcanism
Biosphere
Attributes of Repository Performance
Water Contacting Waste Package
Waste Package Lifetime
Radionuclide Mobilization and Release
Radionuclide Transport
Disruptive Events and Processes

Summary of Supplemental Models and Analyses

Key Attributes Of System	Process Model (Section of Yucca Mountain Science and Engineering Report [DOE, 2001])	Topic Of Supplemental Scientific Model Or Analysis	Reason For Supplemental Scientific Model Or Analysis			Section Of Vol. 1
			Unquantified Uncertainty Analysis	Update in Scientific Information	Cooler Thermal Operating Mode Analysis	
Limited Water Entering Emplacement Drifts	Climate (4.2.1)	Post-10,000 Year Climate Model		X		3.3.1
	Net Infiltration (4.2.1)	Infiltration for post-10,000 yr Climate Model		X		3.3.2
	Unsaturated Zone Flow (4.2.1)	Flow in PTn		X		3.3.3
		3-D flow fields for cooler design; flow fields for post-10,000 yr climate, lateral flow; variable thickness of PTn; fault property uncertainty		X	X	3.3.4
		Effects of lithophysal properties on thermal properties		X	T	3.3.5
	Coupled Effects on UZ Flow (4.2.2)	Mountain-scale Thermal-Hydrologic effects		X	X T	3.3.5
		Mountain-scale Thermal-Hydrologic-Chemical effects		X	X T	3.3.6
		Mountain-scale Thermal-Hydrologic-Mechanical effects		X	X T	3.3.7
	Seepage into Emplacement Drifts (4.2.1)	Flow-focussing within heterogeneous permeability field; episodic seepage	X		X T	4.3.1, 4.3.2, 4.3.5
		Effects rock bolts and drift degradation on seepage	X			4.3.3, 4.3.4
	Coupled Effects on Seepage (4.2.2)	Thermal effects on seepage	X		X T	4.3.5
		Thermal-Hydrologic-Chemical effects on seepage	X		X T	4.3.6
		Thermal-Hydrologic-Mechanical effects on seepage		X	X T	4.3.7

T = Thermal Dependence
X = Reason topic was analyzed

Table 1-1. Summary of Supplemental Models and Analyses (Continued)

Key Attributes Of System	Process Model (Section of Yucca Mountain Science and Engineering Report [DOE, 2001])	Topic Of Supplemental Scientific Model Or Analysis	Reason For Supplemental Scientific Model Or Analysis			Section Of Vol. 1
			Unquantified Uncertainty Analysis	Update in Scientific Information	Cooler Thermal Operating Mode Analysis	
Long-Lived Waste Package and Drip Shield	Water Diversion Performance of EBS (4.2.3)	Multiscale thermal-hydrologic model, including effects of rock dryout	X		X T	5.3.1
		Thermal property sets	X	X	T	5.3.1
		Effect of in-drift convection on temperatures, humidities, invert saturations, and evaporation rates	X		X T	5.3.2
		Composition of liquid and gas entering drift	X		X T	6.3.1
		Evolution of in-drift chemical environment	X		X T	6.3.3
		Thermo-Hydro-Chemical model comparison to plug-flow reactor and fracture plugging experiment		X T		6.3.1
		Rockfall		X		6.3.5
	In-Drift Moisture Distribution (4.2.5)	Environment on surface of drip shields and waste packages	X T		T	5.3.2
		Condensation under drip shields	X T			8.3.2
		Evaporation of seepage	X		X T	8.3.1 5.3.2
		Effect of breached drip shields or waste package on seepage	X		X	8.3.3
		Waste package release flow geometry (flow-through, bathtub)	X			8.3.4
	Drip Shield Degradation and Performance (4.2.4)	Local chemical environment on surface of drip shields (including Mg, Pb) and potential for initiating localized corrosion	X			7.3.1

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Table 1-1. Summary of Supplemental Models and Analyses (Continued)

Key Attributes Of System	Process Model (Section of Yucca Mountain Science and Engineering Report [DOE, 2001])	Topic Of Supplemental Scientific Model Or Analysis	Reason For Supplemental Scientific Model Or Analysis			Section Of Vol. 1
			Unquantified Uncertainty Analysis	Update in Scientific Information	Cooler Thermal Operating Mode Analysis	
Long-Lived Waste Package and Drip Shield	Waste Package Degradation and Performance (4.2.4)	Local chemical environment on surface of waste packages (including Mg, Pb) and potential for initiating localized corrosion	X		X T	7.3.1 7.3.7
		Aging and phase stability effects on A-22	X T	X	T	7.3.2
		Uncertainty in weld stress state following mitigation	X			7.3.3
		Weld defects	X			7.3.3
		Early failure due to improper heat treatment	X		X T	7.3.6
		General corrosion rate of A-22: Temperature dependency	X		X T	7.3.5
		General corrosion rate of A-22: Uncertainty/variability partition	X			7.3.5
		Long-term stability of passive films on A-22	X	T		7.3.4
		Stress threshold for initiation of stress corrosion cracking	X	X	X	7.3.3
		Probability of non-detection of manufacturing defects		X		7.3.4
		Number of defects		X		7.3.5
		Distribution of crack growth exponent (repassivation slope)	X	X		7.3.7
Limited Release of Radionuclides from the Engineered Barriers	In-Package Environments (4.2.6)	Effect of HLW glass degradation rate and steel degradation rate on in-package chemistry	X		X T	9.3.1
	Cladding Degradation and Performance (4.2.6)	Effect of initial perforations, creep rupture, stress corrosion cracking, localized corrosion, seismic failure, rock overburden failure, and unzipping velocity on cladding degradation	X		X T	9.3.3

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Table 1-1. Summary of Supplemental Models and Analyses (Continued)

Key Attributes Of System	Process Model (Section of Yucca Mountain Science and Engineering Report [DOE, 2001])	Topic Of Supplemental Scientific Model Or Analysis	Reason For Supplemental Scientific Model Or Analysis			Section Of Vol. 1
			Unquantified Uncertainty Analysis	Update in Scientific Information	Cooler Thermal Operating Mode Analysis	
Limited Release of Radionuclides from the Engineered Barriers	DHLW Degradation and Performance (4.2.6)	HLW glass degradation rates	X	X	X T	9.3.1
	Dissolved Radionuclide Concentrations (4.2.6)	Solubility of neptunium, thorium, plutonium, and technetium	X	X	X T	9.3.2
	Colloid-Associated Radionuclide Concentrations (4.2.6)	Colloid mass concentrations	X			9.3.4
	In-Package Radionuclide Transport (4.2.6)	Diffusion inside waste package	X	X	X T	10.3.1
		Transport pathway from inside waste package to invert	X	X		10.3.2
		Sorption inside waste package	X	X		10.3.4
	EBS (Invert) Degradation and Performance (4.2.7)	Sorption in invert	X	X		10.3.4
		Diffusion through invert	X		X T	10.3.3
		Colloid stability in the invert	X T			10.3.5
		Microbial transport of colloids	X	X		10.3.6

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Table 1-1. Summary of Supplemental Models and Analyses (Continued)

Key Attributes Of System	Process Model (Section of Yucca Mountain Science and Engineering Report [DOE, 2001])	Topic Of Supplemental Scientific Model Or Analysis	Reason For Supplemental Scientific Model Or Analysis			Section Of Vol. 1
			Unquantified Uncertainty Analysis	Update in Scientific Information	Cooler Thermal Operating Mode Analysis	
Delay and Dilution of Radionuclide Concentrations by the Natural Barriers	Unsaturated Zone Radionuclide Transport (Advective Pathways; Retardation; Dispersion; Dilution) (4.2.8)	Effect of drift shadow zone - advection/diffusion splitting	X		X T	11.3.1
		Effect of drift shadow zone – concentration boundary condition on EBS release rates	X			11.3.1
		Effect of matrix diffusion	X			11.3.2, 11.3.3
		3-D transport			X	11.3.4
		Effect of coupled Thermo-Hydrologic, Thermo-Hydro-Chemical, and Thermo-Hydro-Mechanical processes on transport		X	X T	11.3.5
	Saturated Zone Radionuclide Transport (4.2.9)	Groundwater specific discharge uncertainty	X			12.3.1
		Effective diffusion coefficient in volcanic tuffs	X			12.3.2
		Flowing interval spacing				12.3.2
		Flowing interval (fracture) porosity, enhanced matrix diffusion case	X			12.3.2
		Effective porosity in the alluvium	X			12.3.2
		Correlation of the effective diffusion coefficient with matrix porosity	X			12.3.2
		Bulk density of the alluvium	X	X		12.3.4

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Table 1-1. Summary of Supplemental Models and Analyses (Continued)

Key Attributes Of System	Process Model (Section of Yucca Mountain Science and Engineering Report [DOE, 2001])	Topic Of Supplemental Scientific Model Or Analysis	Reason For Supplemental Scientific Model Or Analysis: Unquantified Uncertainty Analysis	Update in Scientific Information	Cooler Thermal Operating Mode Analysis	Section Of Vol. 1
Delay and Dilution of Radionuclide Concentrations by the Natural Barriers	Saturated Zone Radionuclide Transport (4.2.9)	Retardation for radionuclides irreversibly sorbed on colloids in the alluvium	X	X		12.3.2
		No matrix diffusion in volcanic tuffs case				12.5.2
		Presence or absence of alluvium		X		12.5.2
		Sorption coefficient in alluvium for I, Tc	X	X		12.3.2
		Sorption coefficient in alluvium for Np, U	X	X		12.3.2
		Sorption coefficient for Np in volcanic tuffs	X			12.3.2
		Kc model for groundwater colloid concentrations Pu, Am		X		12.5.2
	Biosphere (4.2.10)	Receptor of interest	X			13.3.1
		Comparison of dose assessment methods	X			13.3.2
		Radionuclide removal from soil by leaching	X			13.3.3
		Uncertainties not captured by GENII-S	X			13.3.4
		Influence of climate change on groundwater usage and BDCFs	X			13.3.5, 13.3.7
		BDCF's for groundwater and igneous releases		X		13.3.6, 13.3.8 13.4

X = Reason topic was analyzed

Table 1-1. Summary of Supplemental Models and Analyses (Continued)

Key Attributes Of System	Process Model (Section of Yucca Mountain Science and Engineering Report [DOE, 2001])	Topic Of Supplemental Scientific Model Or Analysis	Reason For Supplemental Scientific Model Or Analysis			Section Of Vol. 1
			Unquantified Uncertainty Analysis	Update in Scientific Information	Cooler Thermal Operating Mode Analysis	
Low Mean Annual Dose Considering Potentially Disruptive Events	Volcanism/Igneous Activity (4.3.2)	Probability of dike intersection of repository for 70,000 MTHM, no backfill, design		X		14.3.3.1
		Scaling factors to evaluate impacts of repository design changes			X	14.3.3.2
		Contribution to release of Zones 1 and 2		X		14.3.3.3
		Sensitivity to waste particle size distribution		X		14.3.3.4
		New wind speed data		X		14.3.3.5
		Explanation of method for handling ash/waste particle size and density		X		14.3.3.6
		Volcanism inputs for Supplemental TSPA Model		X		14.3.3.7

X = Reason topic was analyzed

Conclusions - What We Have Learned

- **Quantification of uncertainties has improved our understanding of both conservatisms and non-conservatisms in our process model representations**
- **Reduction of uncertainties can come from operating at either end of the thermal range and depends upon the model of interest**
- **The post-closure impacts of a range of thermal operating modes and a variety operating mode configurations can be evaluated by selecting appropriate thermal initial conditions for the model representations**

Conclusions - What We Have Learned

(Continued)

- Waste Package Degradation evaluations with respect to thermal operating mode must consider thermal dependencies and local chemical environment
- Capturing Multiple Lines of Evidence is a useful exercise in improving our understanding repository processes
- The Supplemental Science and Performance Analyses is not the end of the story - it provides a point of reference for continuing work