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YUCCA
MOUNTAIN
PROJECT

Studies

License Application Plan - Site Investigations Overview

Presented to:
NRCDOE Technical Exchange
License Application Plan

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Legacy/main - xs

Major Objectives of Site Investigations

- Site Data Collection and Testing
  - Support surface and subsurface design
  - Predictive model validation
- Process Models for the Natural Environment
  - Support performance assessment
  - Postclosure performance of design features
- Resolution of Key Technical Issues
- Qualification of Models and Data

Work Categories in the LA Plan

- Geologic Framework and Disruptive Events
- Unsaturated Zone Processes
- Saturated Zone Processes
- Thermal Testing
- Near-Field Environment and Coupled Processes

Principal Factors of Postclosure Performance

Attributes of the Repository Safety Strategy	Principal Factors	Priority (0 = low, 3 = high)
Limited water contacting waste packages	1. Precipitation and infiltration into the mountain	1
	2. Percolation to depth	2
	3. Seepage into drifts	3
	4. Effects of heat and excavation on flow (mountain scale)	1
	4A. Effects of heat and excavation on flow (drift scale)	2
	5. Dripping onto waste package	2
	6. Humidity and temperature at waste package	0
Long waste package lifetime	7. Chemistry of water on waste package	2
	8. Integrity of outer carbon steel waste package barrier	1
	9. Integrity of inner corrosion–resistant waste package barrier	3
Low rate of release of radionuclides from breached waste packages	10. Seepage into waste package	0
	11. Integrity of spent fuel cladding	2
	12. Dissolution of spent fuel and glass waste forms	1
	13. Neptunium solubility	1
	14. Formation and transport of radionuclide-bearing colloids	2
Concentration reduction during transport from waste packages	15. Transport through and out of EBS	1
	16. Transport through unsaturated zone	3
	17. Flow and transport in saturated zone	1
	18. Dilution from pumping	0
	19. Biosphere transport and uptake	0

Site Investigations Planned Technical Work
Geologic Framework and Disruptive Events

Work Category (Section of VA Vol. IV)	Postclosure Safety Case						Preclosure Safety Case
	1. Expected Postclosure Performance		2. Design Margin/ Defense in Depth	3. Disrup-tive Process./ Events	4. Natural & Man-Made Analogs	5. Perfor-mance Confir-mation	
	Principal Factors	Priority					
Geologic and Geotech-nical Subsurface Mapping (3.1.1.1)	Flow and transport in the UZ	3					
Surface Geological Mapping (3.1.1.2)	Flow and transport in the SZ	1					
3-D Integrated Site Model (3.1.1.3)	**Flow and transport in the UZ** **Flow and transport in the SZ**	**3** **1**					
Seismic Engineering Design Input (3.1.1.4)				√			√
Geophysical Investi-gations (3.1.1.5)	Percolation to depth Flow and transport in the UZ	2 3					
Geological/Geophysi-cal Support (3.1.1.6)	Effects of heat/excavation on flow Dripping onto waste packages Flow and transport in the UZ Flow and transport in the SZ	2 2 3 1			√	√	
Design Confirmation (3.1.1.7)	Effects of heat/excavation on flow	2				√	
Thermal/Mechanical Core Testing (3.1.1.8)	Effects of heat/excavation on flow	2					

Example: Geologic Framework and Disruptive Events

3-D Integrated Site Model → fully qualified

Principal Factors

- Flow and Transport in the Unsaturated Zone
- Flow and Transport in the Saturated Zone

Remaining Work for SR/LA

- Update with new data from the Cross-Drift, and Borehole WT-24 & SD-6

Site Investigations Planned Technical Work
Unsaturated Zone Processes

Work Category (Section of VA Vol. IV)	Postclosure Safety Case						Preclosure Safety Case
	1. Expected Postclosure Performance		2. Design Margin/ Defense in Depth	3. Disrup-tive Process./ Events	4. Natural & Man-Made Analogs	5. Perfor-mance Confir-mation	
	Principal Factors	Priority					
Formation of Radionuclide-Bearing Colloids (3.1.2.1)	Formation and transport of radionuclide-bearing colloids Transport through and out of EBS Flow and transport in the unsaturated zone	2 1 3			√		
Transport in the Unsaturated Zone (3.1.2.2)	Formation and transport of radionuclide-bearing colloids Flow and transport in the unsaturated zone	2 3			√		
Water Movement through the Unsaturated Zone (3.1.2.3)	**Precipitation and infiltration into the mountain** **Percolation to depth** **Seepage into drifts** **Flow and transport in the unsaturated zone**	**1** **2** **3** **3**					
Mountain-Scale UZ Flow and Transport Model (3.1.2.4)	Percolation to depth Flow and transport in the unsaturated zone	2 3					
Drift-Scale Unsaturated Zone Flow and Transport Model (3.1.2.5)	Seepage into drifts Effects of heat/excavation on flow Flow and transport in the unsaturated zone	3 2 3					

Example: Unsaturated Zone Processes

Water Movement Through the Unsaturated Zone

Principal Factors

- Precipitation and Infiltration Into the Mountain
- Percolation to Depth
- Seepage Into Drifts
- Flow and Transport in the Unsaturated Zone

Remaining Work for SR/LA

- Complete hydrologic testing in the ESF, including new niche studies
- Continue moisture monitoring in ESF
- Complete geochemical and isotopic analysis of fracture minerals

Site Investigations Planned Technical Work

Saturated Zone Processes

Work Category (Section of VA Vol. IV)	Postclosure Safety Case						Preclosure Safety Case
	1. Expected Postclosure Performance		2. Design Margin/ Defense in Depth	3. Disruptive Process./ Events	4. Natural & Man-Made Analogs	5. Performance Confirmation	
	Principal Factors	Priority					
C-Wells Hydraulic Testing (3.1.3.1)	Formation and transport of radionuclide-bearing colloids Flow and transport in the saturated zone	2 1					
Saturated Zone Hydrochemistry Data (3.1.3.2)	**Neptunium solubility** **Formation and transport of radionuclide-bearing colloids** **Flow and transport in the saturated zone**	**1** **2** **1**					
Early Warning Drilling Program (Nye County) (3.1.3.3)	Flow and transport in the saturated zone	1				√	
Site-Scale Saturated Zone Flow and Transport Model (3.1.3.4)	Flow and transport in the saturated zone	1					
Regional-Scale Saturated Zone Flow Model (3.1.3.5)	Flow and transport in the saturated zone	1					

Example: Saturated Zone Processes

Saturated Zone Hydrochemistry Data

Principal Factors

- Neptunium Solubility
- Formation and Transport of Radionuclide-Bearing Colloids
- Flow and Transport in the Saturated Zone

Remaining Work for SR/LA

- Collect regional data in collaboration with Nye County and the Nevada Test Site will go back to existing SZ wells
- Chemical and isotopic analysis
- Incorporate as constraints on flow and transport

no Np solubility work?

Site Investigations Planned Technical Work
Thermal Testing

Work Category (Section of VA Vol. IV)	Postclosure Safety Case						Preclosure Safety Case
	1. Expected Postclosure Performance		2. Design Margin/ Defense in Depth	3. Disrup-tive Process./ Events	4. Natural & Man-Made Analogs	5. Perfor-mance Confir-mation	
	Principal Factors	Priority					
Large Block Test (3.1.4.1)	Effects of heat/excavation on flow RH and temp. at waste package Chemistry of water on waste package	2 0 2					
Single Heater Test (3.1.4.2)	Effects of heat/excavation on flow RH and temp. at waste package Chemistry of water on waste package	2 0 2					√
Drift Scale Heater Test (3.1.4.3)	**Effects of heat/excavation on flow** **Dripping onto waste package** **Humidity and temperature at waste package** **Chemistry of water on waste package**	**2** **2** **0** **2**				√	√
Cross-Drift Thermal Test (3.1.4.4)	Effects of heat/excavation on flow Humidity and temperature at waste package Chemistry of water on waste package	2 0 2				√	√

Example: Thermal Testing

Drift Scale Heater Test

Principal Factors

- Effects of heat and excavation on flow
- Dripping onto waste package
- Humidity and temperature at waste package
- Chemistry of water on waste package

Remaining Work for SR/LA

- Complete 4-year heating phase in 2001 (followed by cooldown)
- Automatic data collection
- Borehole testing and sampling
- Tomographic imaging & microseismic monitoring

Site Investigations Planned Technical Work

Near-Field Environment and Coupled Processes

Work Category (Section of VA Vol. IV)	Postclosure Safety Case						Preclosure Safety Case
	1. Expected Postclosure Performance		2. Design Margin/ Defense in Depth	3. Disruptive Process./ Events	4. Natural & Man-Made Analogs	5. Performance Confirmation	
	Principal Factors	Priority					
Simulate the Performance of Design Options for the Engineered Barrier System (3.1.5.1)	Effects of heat/excavation on flow Dripping onto waste packages RH and temp. at waste package Chemistry of water on WP's Formation and transport of radionuclide-bearing colloids Transport through/out of EBS	2 2 0 2 2 1	√		√		
Comparative Testing of Candidate Materials (3.1.5.2)	Chemistry of water on WP's Formation and transport of radionuclide-bearing colloids	2 2			√	√	
Mechanical Stability of Ground Support Materials (3.1.5.3)	Chemistry of water on WP's Formation and transport of radionuclide-bearing colloids	2 2					
Thermal-Hydrological-Mechanical Coupled Effects (3.1.5.4)	Effects of heat/excavation on flow Seepage into drifts Dripping onto waste packages	2 3 2			√		
Thermal-Hydrological-Chemical Coupled Effects (3.1.5.5)	**Effects of heat/excavation on flow** **Seepage into drifts** **Dripping onto waste packages** **RH and temp. at waste package** **Chemistry of water on WP's**	**2** **3** **2** **0** **2**					

Example: Near-field Environment and Coupled Processes

Thermal-Hydrological-Chemical Coupled Effects

Principal Factors

- Effects of heat and excavation on Flow
- Seepage into drifts
- Dripping onto waste packages
- Relative humidity and temperature on waste packages
- Chemistry of water on waste packages

Remaining Work for SR/LA

- Update model features
- Perform laboratory validation experiments
- Simulate natural analogs
- Data analysis and reporting

Technical Work Related to Specific NRC KTIs

Elements of Remaining Technical Work Related to NRC KTIs: *Unsaturated and Saturated Flow Under Isothermal Conditions, and Radionuclide Transport*

Unsaturated Zone

- Update the model of infiltration distribution under wetter climate conditions
- Refine the drift seepage model, and incorporate drift geometry altered by rockfall → especially will get some attention
- Predict changes in flow and transport properties from coupled processes
- Measure changes in flow properties in the lab
- Refine the colloidal transport model
- Investigate colloid transport in lab and field

Elements of Remaining Technical Work Related to NRC KTIs: *Evolution of the Near-Field Environment, Thermal Effects on Flow, and Repository Design and Thermomechanical Effects*

- Calibrate thermal-hydrology models to ESF thermal tests
- Develop measures to capture ~~diversion~~ drip shield barrier and design alternative evaluation low-thermal-load performance
- Predict changes in flow properties from thermally driven coupled processes
- Predict bounds on changes in near-field water composition resulting from coupled processes
- Refine models for the effects of introduced materials on the near-field geochemical environment

Elements of Remaining Technical Work Related to NRC KTI: *Container Life and Source Term*

- Develop models for the nature and timing of postclosure rockfall
- Refine models for drift seepage, and temperature and humidity at waste packages
- Predict the extent of salt deposition on waste packages, caused by coupled processes
- Refine models for the effects of introduced materials on the near-field geochemical environment

not performance of waste package design

Elements of Remaining Technical Work Related to NRC KTIs: *Igneous Activity, and Structural Deformation and Seismicity*

- Only limited additional information is needed to represent the likelihood and consequences of disruptive events such as volcanoes, faulting, and earthquakes
- Determine site-specific attenuation of ground motion (primarily for preclosure performance)
- Continue to monitor earthquakes at the surface and in boreholes

Elements of Remaining Technical Work Related to NRC KTIs: *Unsaturated and Saturated Flow Under Isothermal Conditions, and Radionuclide Transport*

Saturated Zone

- Complete multi-well transport testing (C-wells)
- Collect hydrochemical data and samples from existing and new boreholes
- Support Nye County collaborative drilling program help over long time frames
- Refine the SZ groundwater flow model to enhance grid resolution and representation of colloidal transport, and to incorporate new data from testing

goal – improve treatment of dispersion

- Calibrate the SZ model using hydrochemical and isotopic data

Major Site Investigations Milestones to Performance Assessment and Design

UZ Model for SR/LA	2/00
SZ Flow Model for SR/LA	2/00
UZ Transport Model for SR/LA	2/00
SZ Transport Model for SR/LA	2/00
NFE Models for SR/LA	1/00
Single Heater Test Final Report	1/99
Drift-Scale Test Report for SR/LA	9/99

Summary

- Work plans are presented at a summary level
- Planned work will support PA, Design, and resolution of NRC Key Technical Issues
- The LA Plan prioritizes technical work for the Postclosure Safety Case (Element 1 - Expected Performance)
- Prioritization may change based on the selected LA design (5/99)