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

YUCCA MOUNTAIN PROJECT

U.S. Department of Energy Approach to Grouped Resolution of Key Technical Issue Agreements

Presented to:
U.S. Nuclear Regulatory Commission

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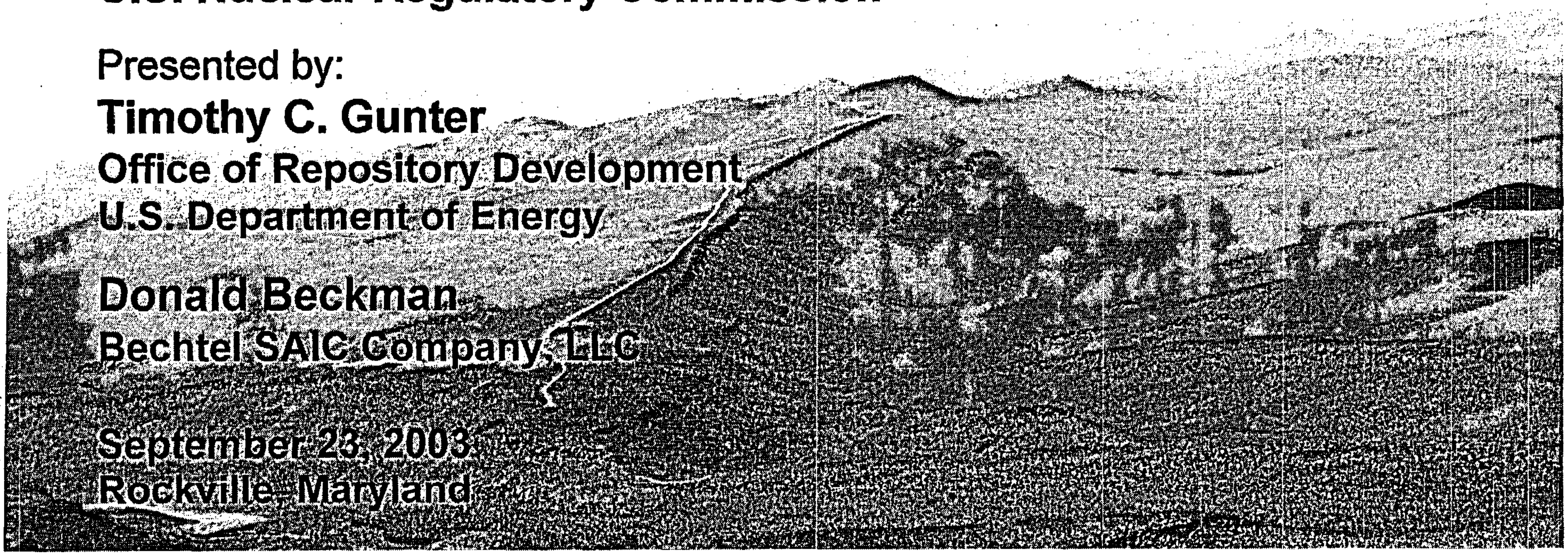


ATTACHMENT 3

U.S. Department of Energy Approach to Key Technical Issue Resolution

- **Introduction**
  - Revisions to resolution strategy were needed
    - Program replanning due to Continuing Resolution
    - Availability of Yucca Mountain Review Plan (YMRP)
    - Increases in understanding due to communications with NRC staff
    - Developing responses to original Key Technical Issue (KTI) agreements
    - Receipt of Additional Information Needed (AIN) from NRC staff
    - Clarification of NRC staff expectations
    - Discussions at technical exchanges
  - Previous approach focused primarily on responses to individual agreements
    - Addressing each agreement in isolation was not as effective as an integrated approach

U.S. Department of Energy Approach to Key Technical Issue Resolution

(Continued)

- Revised approach reflects a total postclosure system view
  - KTI agreements will be addressed according to their relationship to the repository system
  - Consistent with the YMRP and the Safety Analysis Report
  - A more integrated, systematic approach to address KTI agreements

Key Technical Issue Group Response Approach

- 194 KTI agreements and AINs mapped to logical groupings for which a Technical Basis Document will be prepared
- Grouped KTI agreement response deliveries begin Fall 2003 and continue through 2004
- Remaining KTI agreements not associated with postclosure processes scheduled individually
  - Delivered in parallel with grouped KTI agreements and AINs through mid-2004

Key Technical Issue Group Response Approach

(Continued)

- DOE is providing a Technical Basis Document for each group topic
- Individual KTI agreements and AIN responses are discreetly addressed in Appendices to the Technical Basis Document
- The Technical Basis Document will provide the broad context of postclosure repository performance to which the KTI responses relate

Integrated Technical Basis Key Technical Issue Response Groups

(and Related Process Model Groups)

I. Climate and infiltration

II. Unsaturated zone flow

III. Water seeping into drifts
- Water seeping into drifts
- Thermal effects on water flow

IV. Mechanical degradation and seismic effects

V. In-drift chemical environment
- Thermal effects on water flow and chemistry
- Evaporation effects on in-drift water flow and chemistry
- Chemistry modification by dust and deliquescence

VI. Waste package and drip shield corrosion
- Degradation of the drip shield
- Degradation of the waste package

VII. In-package environment, waste form degradation and solubility
- Water and chemistry evolution in the waste package
- Degradation of waste form
- Mobilization of radionuclides

VIII. Colloid transport
- Mobilization of radionuclides
- Transport to edge of waste package
- Transport to invert
- Transport to rock
- Unsaturated zone transport
- Saturated zone flow and transport

IX. Engineered barrier system transport
- Thermal effects on water flow and chemistry
- Transport to edge of waste package
- Transport to invert
- Transport to rock

X. Unsaturated zone transport
- Thermal effects on transport
- Unsaturated zone transport

XI. Saturated zone flow and transport

XII. Biosphere transport

XIII. Volcanic events

XIV. Low probability seismic events

Technical Basis Document Content

- Detailed discussion of scientific basis with focus on physical processes and phenomena
- Integration of topics crossing process/group interfaces or affecting boundary conditions
- Consideration of Yucca Mountain Project and NRC risk prioritization and ranking information

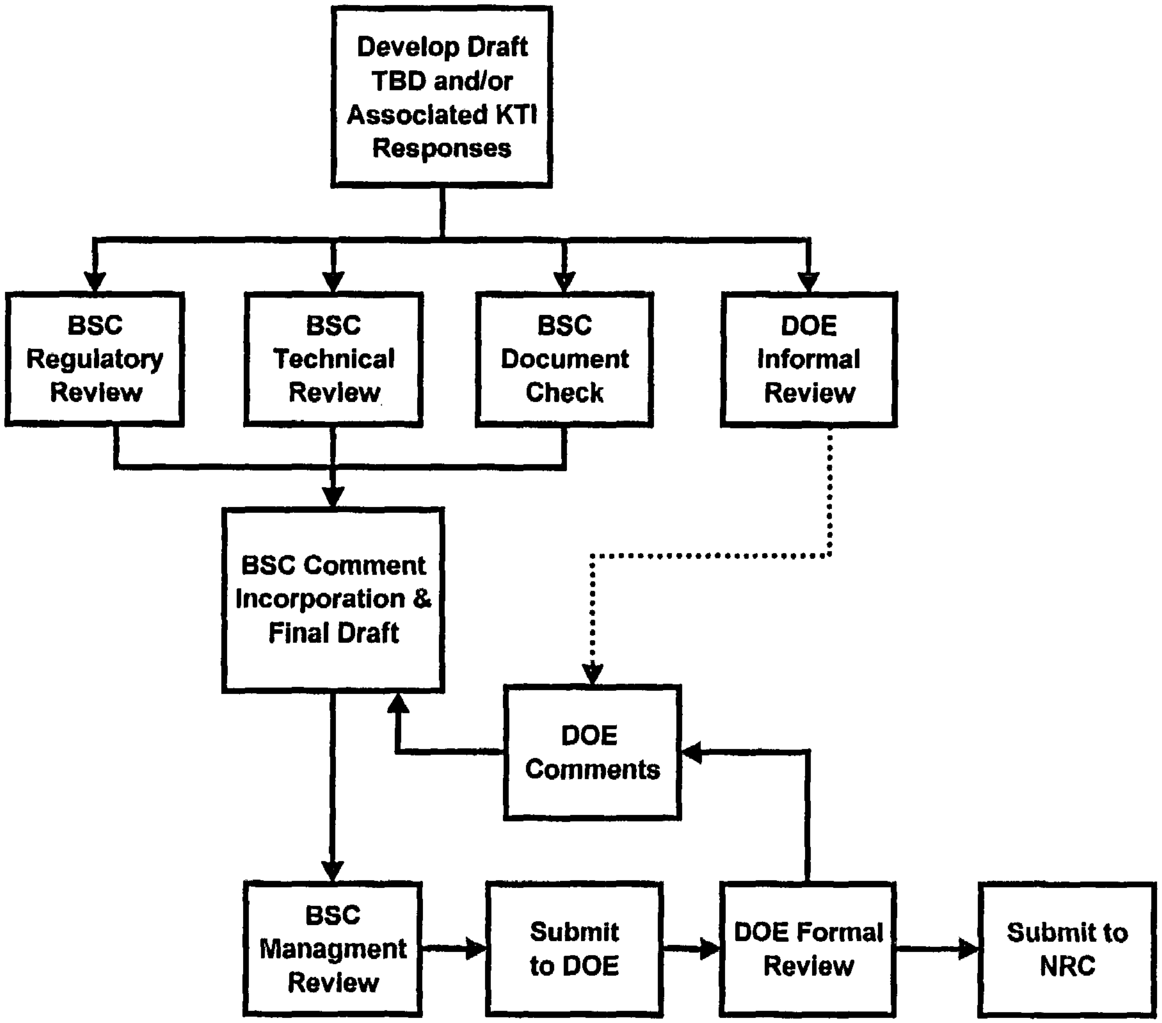
Technical Basis Document
Key Technical Issue Content

- **Focus on repository system and process level with emphasis on physical performance**
  - Currently running about 150-200 pages each
  - KTI agreements broadly addressed in Technical Basis Documents when appropriate
  - Detailed Technical Basis Documents text, at a minimum, provides the overall context for detailed discussion in the corresponding KTI appendix
  - Scope envelopes all relevant KTI agreements
  - Back-Reference from KTI agreements to Technical Basis Document text provided

Key Technical Issue Appendix Content

- Individual Technical Basis Document Appendices provided *for* each KTI and/or AIN
  - Text responsive to NRC information request
  - Provides robust basis as to why NRC information request is no longer germane
  - Provides alternative information, as appropriate
- Some sub-grouping of identical or closely related KTI agreements are handled in single appendix
- Established processes for preparation of licensing documents used to prepare both Technical Basis Documents and KTI agreement responses

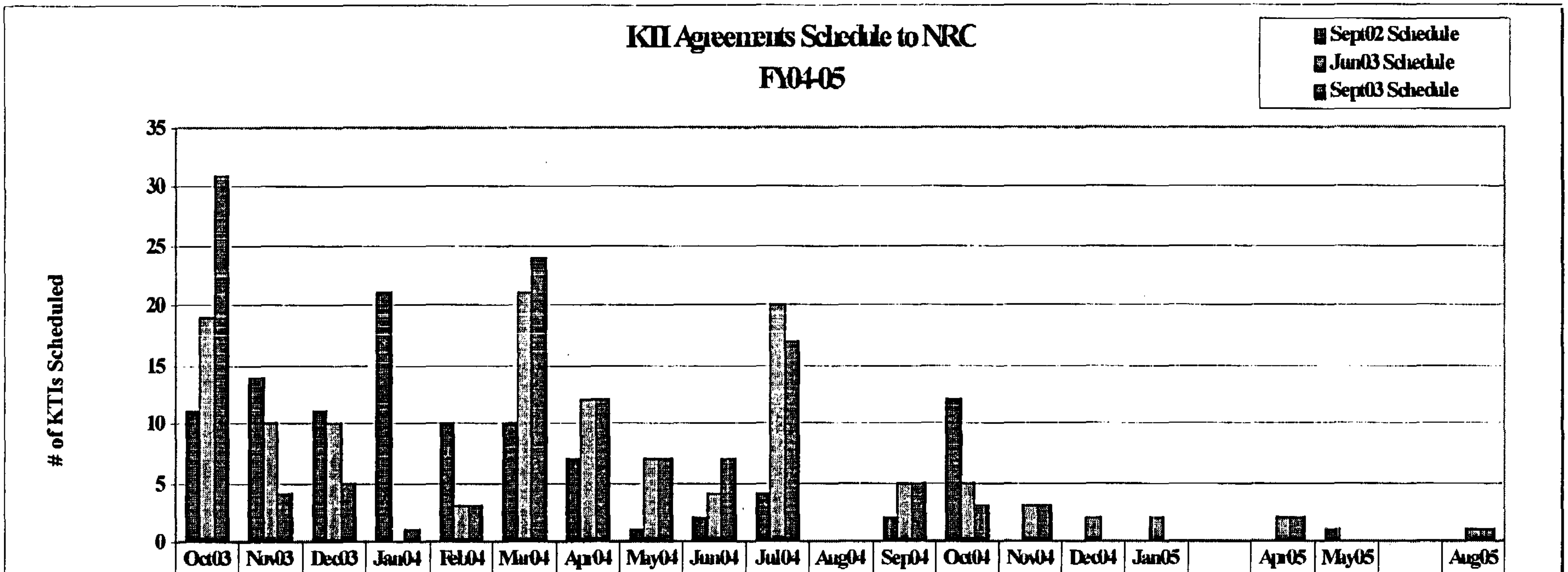
Key Technical Issue Development Process



Key Technical Issue Schedule

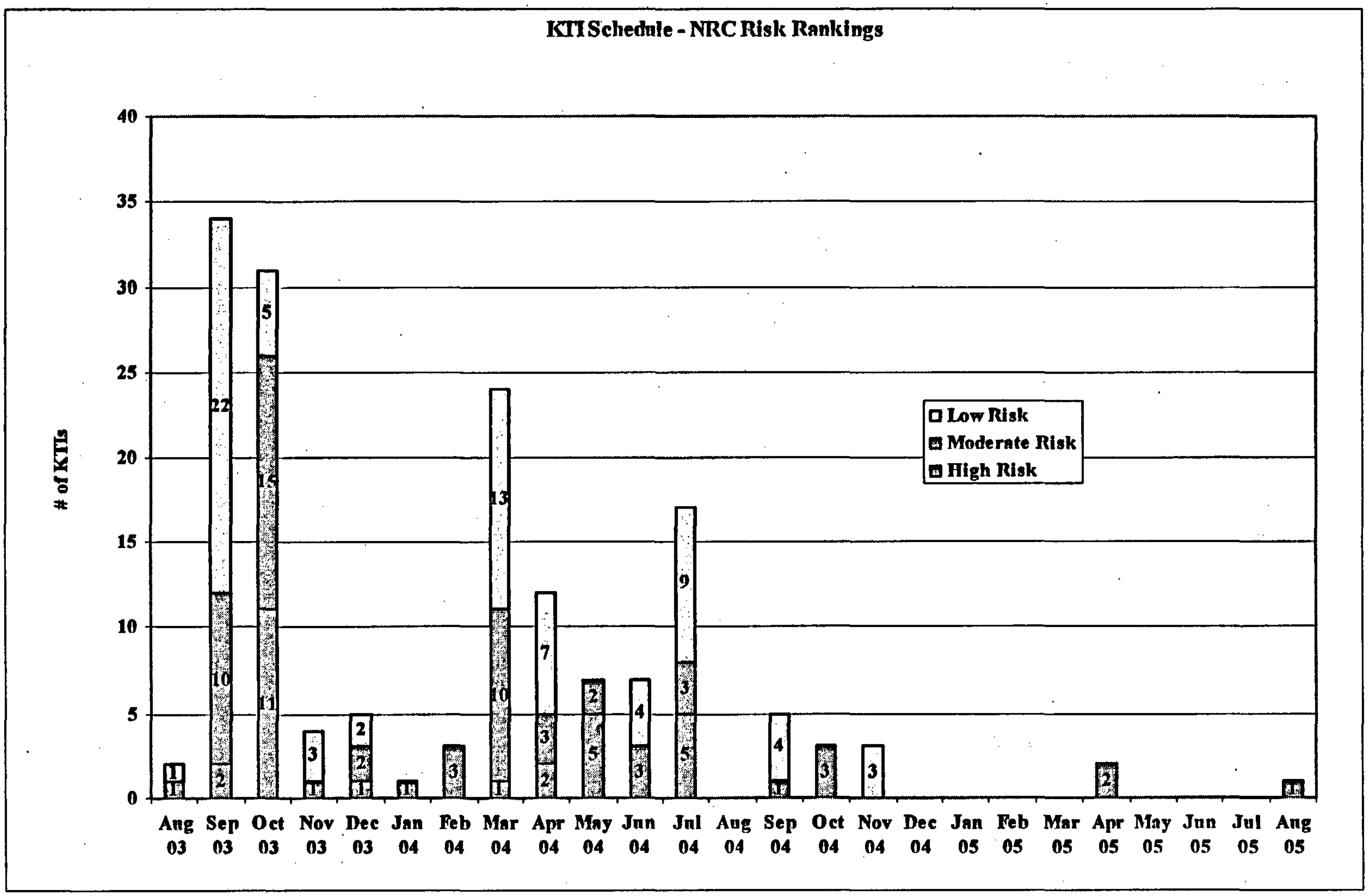
- **All KTI agreements will be addressed by the time the License Application (LA) is submitted**
- **KTI agreements with ongoing work scheduled past LA will be addressed about 6 months prior to LA submittal**
  - **Will provide development status of final resolution**
  - **Will address acceptability of interim status to support LA**

Key Technical Issue Response Schedule - FY 03-05

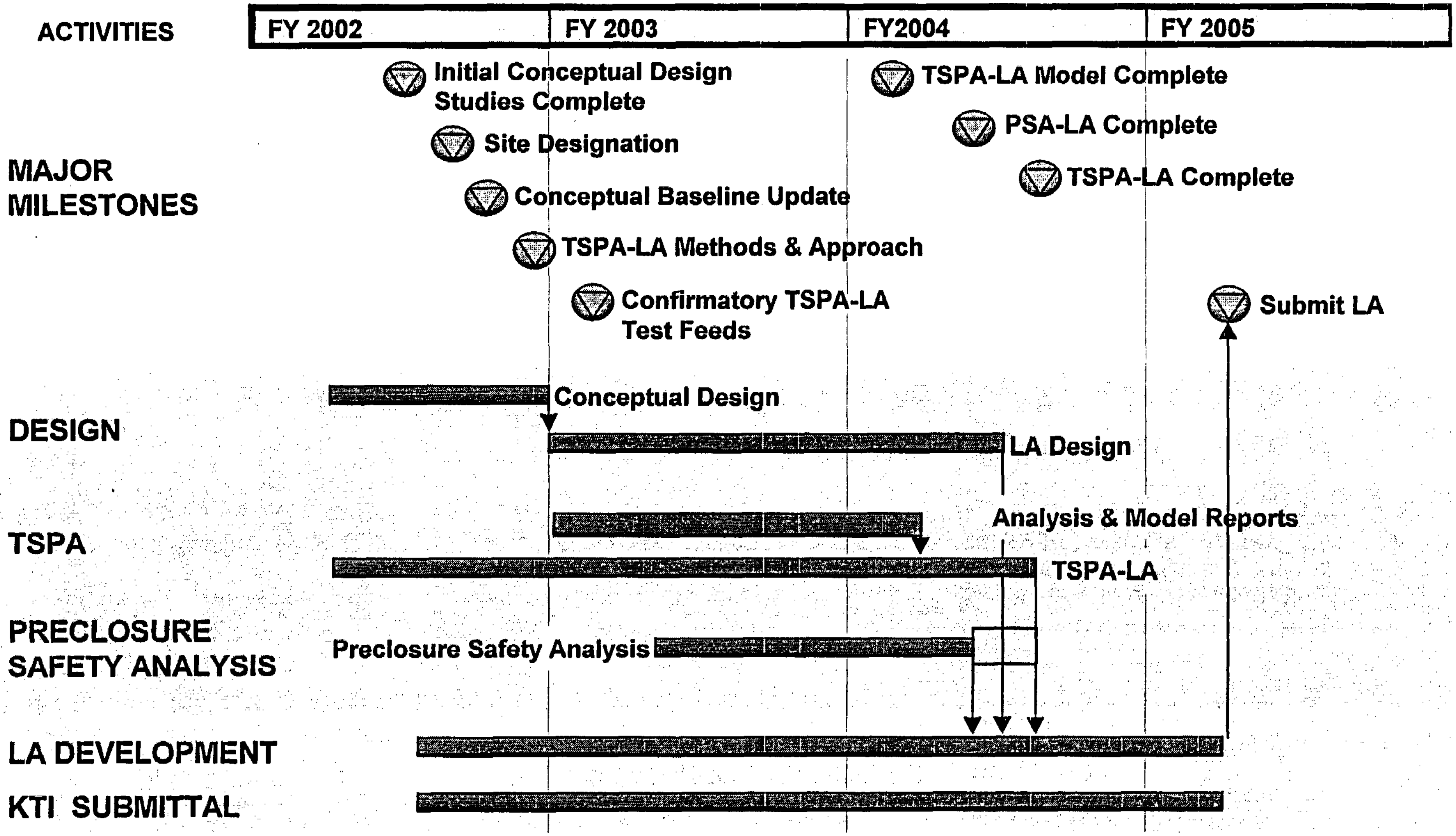


	Oct03	Nov03	Dec03	Jan04	Feb04	Mar04	Apr04	May04	Jun04	Jul04	Aug04	Sep04	Oct04	Nov04	Dec04	Jan05		Apr05	May05		Aug05
Sept02 Schedule	11	14	11	21	10	10	7	1	2	4	0	2	12						1		
Jun03 Schedule	19	10	10	0	3	21	12	7	4	20	0	5	5	3	2	2		2			1
Sept03 Schedule	31	4	5	1	3	24	12	7	7	17	0	5	3	3				2			1

Key Technical Issue Schedule – U.S. Nuclear Regulatory Commission Risk Rankings



Summary Schedule to License Application Submittal



Summary

- KTI schedule will be aggressively managed to assure earliest practical delivery of information addressing NRC's needs
- Will address all KTI agreements prior to LA
- KTI agreements with work ongoing past LA will have sufficient technical basis to support NRC's LA technical adequacy review

Supporting Information

Key Technical Issue Response Groups and Due Dates to U.S. Nuclear Regulatory Commission

	Technical Basis Document – Response Group	Due to NRC
BC/TSPAI	Barrier Capability/Total System Performance Assessment and Integration	Sep 2004
CRIT	Criticality	Jul 2004
FEP	Features, Events, and Processes	Apr 2004
I	Climate and Infiltration	Mar 2004
II	Unsaturated Flow	Mar 2004
III	Water Seeping into Drifts	Oct 2003*
IV	Mechanical Degradation and Seismic Effects	Jul 2004*
V	In-Drift Chemical Environment	Oct 2003
VI	Waste Package and Drip Shield Corrosion	Oct 2003*
VII	In-Package Environment, Waste Form Degradation and Solubility	Jul 2004*

* Not all KTI agreements to be delivered on this date

Key Technical Issue Response Groups and Due Dates to U.S. Nuclear Regulatory Commission

(Continued)

	Technical Basis Document – Response Group	Due to NRC
VIII	Colloids	Sep 2003
IX	Engineered Barrier System Transport	Jun 2004
X	Unsaturated Zone Transport	Mar 2004
XI	Saturated Zone Flow and Transport	Sep 2003
XII	Biosphere Transport	Sep 2003
XIII	Volcanic Events	Oct 2003
XIV	Low Probability Seismic Events	Feb 2004*
U	Ungrouped	Various

* Not all KTI agreements to be delivered on this date

Technical Basis Document (TBDoc) and Supporting KTIs		KTI Response Groups from 6/23/03 letter
Climate and Infiltration		
TSPAI.3.18.AIN-1	Water-balance plug-flow model and non-linear flow represented by Richards' equation	I. CLIMATE & INFILTRATION
TSPAI.3.19.AIN-1	Justify use of the evapotranspiration model and the analog site temperature data	I. CLIMATE & INFILTRATION
TSPAI.3.21.AIN-1	Effects of near surface lateral flow on the spatial variability of net infiltration	I. CLIMATE & INFILTRATION
USFIC.3.01.AIN-1	Document sources and schedule for the Monte Carlo method for analyzing infiltration	I. CLIMATE & INFILTRATION
USFIC.3.02.AIN-1	Infiltration Uncertainty AMR; Alcove 1 and Pagany Wash Tests	I. CLIMATE & INFILTRATION
Unsaturated Zone Flow		
ENFE.2.03	Provide the technical basis for FEP 1.2.06.00 (Hydrothermal Activity)	FEATURES, EVENTS, PROCESSES
RT.1.01	Provide the basis for the proportion of fracture flow through the Calico Hills non-welded vitric	X. UZ TRANSPORT
RT.3.02	Geochemical data used for support of the flow field below the repository	X. UZ TRANSPORT
TEF.2.11	Updated Calibrated Properties Model AMR	II. UZ FLOW
TEF.2.12	UZ flow and transport documentation	UNGROUPED

Technical Basis Document (TBDoc) and Supporting KTIs		KTI Response Groups from 6/23/03 letter
TEF.2.13. AIN-1	Models for UZ Flow and Transport AMR, and Hydrologic Properties Data AMR	II. UZ FLOW
TSPAI.3.22.AIN-1	Uncertainty in calibrating a current climate model and using to forecast future climate flow	I. CLIMATE & INFILT
TSPAI.3.24	Analysis of geochemical and hydrological data used for flow field below repository	X. UZ TRANSPORT
TSPAI.3.26	Calibrate UZ flow model using recent data on saturations and water potentials	II. UZ FLOW
TSPAI.3.27	Provide an overview of water flow rates used in the UZ model	II. UZ FLOW
USFIC.4.04	Effectiveness of the PTn to dampen episodic flow, including chloride-36 studies	II. UZ FLOW
Water Seeping into Drifts		
TEF.2.08	Updated Mountain-Scale Coupled Processes Model AMR.	III. WATER SEEPING INTO DRIFTS
TSPAI.3.25	Testing to revise the TSPA seepage abstraction and associated parameter values	III. WATER SEEPING INTO DRIFTS
USFIC.4.01	Hydrologic Tests: Alcove 8/Niche 3; Cross Drift; Alcove 7; Niche 5	III. WATER SEEPING INTO DRIFTS
USFIC.4.06	Document results of Comparison of Continuum and Discrete Fracture Network Models study	III. WATER SEEPING INTO DRIFTS

Technical Basis Document (TBDoc) and Supporting KTIs		KTI Response Groups from 6/23/03 letter
RT.3.06.AIN-1	Pre-test predictions for Phase II (flow & transport); related to TSPAI 3.25	UNGROUPED
SDS.3.02.AIN-1	Document the pre-test predictions for the Alcove 8 Niche 3 work	III. WATER SEEPING INTO DRIFTS
ENFE.1.03.AIN-1	Drift-Scale Coupled Processes (DST and THC Seepage) Models AMR, ReV. IN-DRIFT In-Drift Chemical Environment01 & 02	III. WATER SEEPING INTO DRIFTS
ENFE.1.04	The effects of cementitious materials on hydrologic properties	III. WATER SEEPING INTO DRIFTS
RT.3.05	Alcove 8/Niche 3 testing and predictive modeling for the UZ	X. UZ TRANSPORT
SDS.3.01 & SDS.3.01.AIN-1	The ECRB and Alcove 8 Niche 3 tests need to be related to observed fracture patterns	III. WATER SEEPING INTO DRIFTS
TEF.2.10.AIN-1	Variability/uncertainty in TEF simulations in the abstraction of thermodynamic variables	III. WATER SEEPING INTO DRIFTS
TSPAI.3.07	Representation of, or the neglect of, dripping from rockbolts in the ECRB	III. WATER SEEPING INTO DRIFTS
RDTME.3.20	Sensitivity analyses of thermal-mechanical effects on fracture permeability	UNGROUPED
RDTME.3.21	Validation analysis of field tests re TM effects on fracture permeability	UNGROUPED
TSPAI.3.11	Integration between the 3D UZ flow model, MSTH model, and drift seepage model	II. UZ FLOW
USFIC.6.03	Complete the Alcove 8 testing	III. WATER SEEPING INTO DRIFTS

Technical Basis Document (TBDoc) and Supporting KTIs		KTI Response Groups from 6/23/03 letter
Mechanical Degradation and Seismic Effects		
RDTME.3.04	Site-specific properties of the host rock	IV. MECH DEGRADATION
RDTME.3.05	Technical basis for accounting for the effects of lithophysae	IV. MECH DEGRADATION
TEF.2.07	Provide the Ventilation Model AMR and Pre-Test Predictions for Ventilation Test Calculation	IV. MECH DEGRADATION
RDTME.3.02	Critical combinations of in-situ, thermal, and seismic stresses	IV. MECH DEGRADATION
RDTME.3.06	Design sensitivity and uncertainty analyses of the rock support system	IV. MECH DEGRADATION
RDTME.3.08	Design sensitivity and uncertainty analyses of fracture patterns	IV. MECH DEGRADATION
RDTME.3.09	Rock movements in the invert	IV. MECH DEGRADATION
RDTME.3.10	Two-dimensional modeling for emplacement drifts	IV. MECH DEGRADATION
RDTME.3.11	Continuum and discontinuum analyses of ground support system performance	IV. MECH DEGRADATION
RDTME.3.12	Dynamic analyses of ground support system performance	IV. MECH DEGRADATION
RDTME.3.13	Boundary conditions:continuum/ discontinuum modeling, underground facility design	IV. MECH DEGRADATION
RDTME.3.15	Data and analysis of rock bridges between rock joints	IV. MECH DEGRADATION

Technical Basis Document (TBDoc) and Supporting KTIs		KTI Response Groups from 6/23/03 letter
RDTME.3.16	Modeling joint planes as circular discs; re small trace length fractures	IV. MECH DEGRADATION
RDTME.3.19	Determine whether rockfall can be screened out from PA abstractions	IV. MECH DEGRADATION
In-drift Chemical Environment		
CLST.1.01	Titanium corrosion. Effects of brine. Characterize YM brine	IV. MECH DEGRADATION
TSPAI.3.12	Complete testing of corrosion in the chemical environments predicted by the model	III. WATER SEEPING INTO DRIFTS
TSPAI.3.13	Compare predicted corrosion environments to the testing environments used	IV. MECH DEGRADATION
ENFE.1.05	Address the various sources of uncertainty in the THC model	III. WATER SEEPING INTO DRIFTS
TSPAI.3.09	Uncertainty and variability in the near-field environment abstractions in the TSPA	III. WATER SEEPING INTO DRIFTS
ENFE.2.04	Technical basis for bounding the trace elements and fluoride. Effect on drip shield and WP	V. IN-DRIFT
ENFE.2.05	Evaluate data and model uncertainties for specific in-drift geochemical environment submodels	III. WATER SEEPING INTO DRIFTS
ENFE.2.06	Range of local chemistry conditions at the DS and WP, including chemical divide phenomena	V. IN-DRIFT
ENFE.2.09	Provide the In-Drift Precipitates/Salts Analysis AMR	V. IN-DRIFT
ENFE.2.15	Provide the additional data to constrain the interpolative low relative humidity salts model	V. IN-DRIFT

Technical Basis Document (TBDoc) and Supporting KTIs		KTI Response Groups from 6/23/03 letter
ENFE.2.10	Range of composition of waters that could contact the drip shield or WP	III. WATER SEEPING INTO DRIFTS
ENFE.2.11	Current treatment of the kinetics of chemical processes in the in-drift geochemical models	V. IN-DRIFT
ENFE.2.13	Deposition of dust and its impact on the salt analysis	V. IN-DRIFT
ENFE.2.14	Provide the analysis of laboratory solutions that have interacted with introduced materials	V. IN-DRIFT
ENFE.2.17	Document data used to calibrate models and data to support model predictions	V. IN-DRIFT
TEF.2.04	Provide the Multi-Scale Thermohydrologic Model AMR, ReV. IN-DRIFT In-Drift Chemical Environment01	IV. MECH DEGRADATION
TEF.2.05	Represent the "cold-trap" effect in the Multi-Scale Thermohydrologic Model AMR	IV. MECH DEGRADATION
TSPAI.3.10	Integrated uncertainty analyses of EBS physical and chemical environment	III. WATER SEEPING INTO DRIFTS
Waste Package and Drip Shield Corrosion		
CLST.1.07.AIN-1	WP - corrosion measurement and standards	V. IN-DRIFT
CLST.1.13	Stresses due to laser peening and induction annealing of Alloy 22	V. IN-DRIFT
CLST.1.14	Effect of rockfall drift collapse on stress-corrosion cracking of the WP and DS	V. IN-DRIFT
CLST.1.15	Alloy 22 & titanium: install specimens cut from welds of SR design mock-up in LTCTF, etc	V. IN-DRIFT VI. WASTE PACKAGE
CLST.1.16	Measured thermal profile of the WP material due to induction annealing	V. IN-DRIFT

Technical Basis Document (TBDoc) and Supporting KTIs		KTI Response Groups from 6/23/03 letter
RDTME.3.18	Provide a technical basis for a stress measure for use in stress corrosion cracking	V. IN-DRIFT
CLST.1.12	Stress crack corrosion in Alloy 22 and titanium	V. IN-DRIFT
CLST.6.02.AIN-1	Drip shield - Critical hydrogen concentration	V, IN-DRIFT
CLST.6.03.AIN-1	Drip shield - Effect of fluoride on hydrogen uptake	V, IN-DRIFT
CLST.1.06.AIN-1	WP - Effects of silica on corrosion	V. IN-DRIFT
TSPAI.3.03.AIN-1	WP/DS - Stress corrosion cracking (SCC) (NRC Rejected Bin 3)	V. IN-DRIFT
TSPAI.3.01	Propogation of uncertainty of WP & DS Corrosion Rates	V. IN-DRIFT
TSPAI.3.04	Representation of variation of general corrosion rates	V. IN-DRIFT
TSPAI.3.05	Technical basis for uncertainty/variability in general corrosion rates	V. IN-DRIFT
CLST.1.02	Corrosion: Surface analysis of welded specimens; dissolution, dealloying	IV. MECH DEGRADATION
CLST.2.01	Drip shield - rockfall analysis (AMR ANL-XCS-ME-000001)	IV. MECH DEGRADATION
CLST.2.02	Documentation for the point loading rockfall analysis	IV. MECH DEGRADATION
CLST.2.08	WP - Effects of Phase Instability of Materials and Initial Defects	IV. MECH DEGRADATION
CLST.2.09	DS & WP mechanical analysis of seismic excitation and design basis earthquake	IV. MECH DEGRADATION
CLST.1.03	WP - Revision to AMR "General and Localized Corrosion of WP Outer Barrier"	VI. WASTE PACKAGE
CLST.1.08	WP & DS - AMR ANL-EBS-MD-000003 and 000004	VI. WASTE PACKAGE

Technical Basis Document (TBDoc) and Supporting KTIs		KTI Response Groups from 6/23/03 letter
CLST.1.09	WP & DS - Passive film stability - AMR ANL-EBS-MD-000003 & 000004	VI. WASTE PACKAGE
CLST.1.10	Alloy 22 & titanium: Measure corrosion potentials in the LTCTF, etc.	VI. WASTE PACKAGE
CLST.1.11	Critical potentials as bounding parameters for localized corrosion	VI. WASTE PACKAGE
CLST.6.01	Perform more sensitivity measurements of general corrosion rates, etc	V. IN-DRIFT
CLST.2.03.AIN-1	WP/DS - Material analysis, primarily drip shield	IV. MECH DEGRADATION
PRE.7.03	WP - microstructural and compositional variations of alloy 22	IV. MECH DEGRADATION
PRE.7.05	WP - waste package closure wel	IV. MECH DEGRADATION
CLST.2.04	WP - effect of fabrication sequence on phase instability of Alloy 22	VI. WASTE PACKAGE
CLST.2.05	WP - Provide "Aging and Phase Stability of Waste Package Outer Barrier," AMR	VI. WASTE PACKAGE
CLST.1.04	Documentation for Alloy 22 and titanium	V. IN-DRIFT VI. WASTE PACKAGE
In-package Environment, Waste Form Degradation and Solubility		
CLST.3.06.AIN-1	Technical basis for the failure rate and how the rate is affected by localized corrosion	VII. IN-PACKAGE ENVIRONMENT
CLST.3.07	Address chloride induced localized corrosion and SCC	VII. IN-PACKAGE ENVIRONMENT
CLST.3.08.AIN-1	Distribution for cladding temperature and stress used for hydride embritt	VII. IN-PACKAGE ENVIRONMENT
CLST.3.09.AIN-1	Critical stress that is relevant for the environment in which external SCC takes place	VII. IN-PACKAGE ENVIRONMENT

Technical Basis Document (TBDoc) and Supporting KTIs		KTI Response Groups from 6/23/03 letter
CLST.3.02.AIN-1	WF in-package chemistry: Radiolysis, water, corrosion, corrosion products, dissolution	VII. IN-PACKAGE ENVIRONMENT
CLST.3.03.AIN-1	Provide a more detailed calculation on the in-package chemistry effects of radiolysis	VII. IN-PACKAGE ENVIRONMENT
CLST.3.04.AIN-1	Interaction of engineered materials on water chemistry for in-package abstractions	VII. IN-PACKAGE ENVIRONMENT
CLST.3.05	Provide the plan for experiments demonstrating in-package chemistry	VII. IN-PACKAGE ENVIRONMENT
ENFE.3.03	Verify that bulk-scale chemical processes dominate the in-package chemical environment	VII. IN-PACKAGE ENVIRONMENT
ENFE.3.04	Complete validation of in-package chemistry models	VII. IN-PACKAGE ENVIRONMENT
TSPAI.3.08	Abstraction of in-package chemistry and it's implementation into the TSPA	VII. IN-PACKAGE ENVIRONMENT
TSPAI.3.14	Update in-package chemistry model to account for scenarios and their associated uncertainties	VII. IN-PACKAGE ENVIRONMENT
Colloids		
ENFE.1.06	Technical basis for excluding entrained colloids as FEP in Thermo-Chemical Alteration	VI. WASTE PACKAGE,
ENFE.4.04	Technical basis for excluding entrained colloids FEPs analysis (Thermo-Chemical Alteration)	VI. WASTE PACKAGE,
ENFE.4.06 & ENFE.4.06.AIN-1	Provide additional sensitivity analyses of colloid release and transport parameters; sensitivity analysis of colloid transport in NFE;	VI. WASTE PACKAGE,
ENFE.4.03	Basis for screening out coupled THC effects on radionuclide transport properties and colloids	VI. WASTE PACKAGE,
TSPAI.3.30	Contrasting concentrations of colloids available for reversible attachment in the EBS and the SZ	VI. WASTE PACKAGE,

Technical Basis Document (TBDoc) and Supporting KTIs		KTI Response Groups from 6/23/03 letter
RT.3.07	Provide sensitivity studies to test the importance of colloid transport parameters and models	VI. WASTE PACKAGE,
TSPAI.3.17	Transport of dissolved and colloidal radionuclides through the invert	IX. UZ TRANSPORT
RT.1.03.AIN-1	Screening criteria for the radionuclides selected for PA	VIII. COLLOIDS
ENFE.4.05.AIN-1	Provide the screening criteria for the radionuclides selected for PA	VIII. COLLOIDS
ENFE.3.05.AIN-1	Selection of radionuclides that are released via reversible and irreversible attachment to colloids	VIII. COLLOIDS
TSPAI.3.42	Changes in colloid concentrationsdue to shifts in model pH and ionic strength	VI. WASTE PACKAGE,
Engineered Barrier System Transport		
TSPAI.3.16	Evaluate effect of localized flow pathways on water and gas chemistry in the EBS	III. WATER SEEPING INTO DRIFTS
Unsaturated Zone Transport		
RT.1.02	Provide analog radionuclide data from the tracer tests for Calico Hills at Busted Butte	X. UZ TRANSPORT
RT.3.01	Importance of transport through fault zones below the repository	X. UZ TRANSPORT
RT.3.04	Relative importance of hydrogeological units beneath the repository for transport	X. UZ TRANSPORT
RT.3.10	Provide data from analog tracers used at Busted Butte	X. UZ TRANSPORT

Technical Basis Document (TBDoc) and Supporting KTIs		KTI Response Groups from 6/23/03 letter
TSPAI.3.28	Confidence in the active-fracture continuum concept in the transport model	X. UZ TRANSPORT
TSPAI.3.29	Integration of the active fracture model with matrix diffusion in the transport model.	X. UZ TRANSPORT
Saturated Zone Flow and Transport		
USFIC.5.10	Discontinuity between Geologic Framework Model and Hydrogeologic Framework Model	XI. SZ FLOW AND TRANSPORT
RT.2.09.AIN-1	Hydro-stratigraphic cross-sections that include Nye County data	XI. SZ FLOW AND TRANSPORT
USFIC.5.05.AIN-1	Provide hydro-stratigraphic cross-sections that include Nye County data	XI. SZ FLOW AND TRANSPORT
USFIC.5.08	Updated potentiometric data and map for the regional aquifer	XI. SZ FLOW AND TRANSPORT
USFIC.5.02	Update the SZ PMR, considering the updated regional flow model	XI. SZ FLOW AND TRANSPORT
USFIC.5.11.AIN-1	Run SZ flow and transport code assuming a north-south barrier along Solitario Canyon fault	XI. SZ FLOW AND TRANSPORT
USFIC.5.12	Site-Scale Saturated Aone Flow Model calibration and validation	XI. SZ FLOW AND TRANSPORT
USFIC.5.01	Analysis of horizontal anisotropy in C-wells report	XI. SZ FLOW AND TRANSPORT
USFIC.5.06	Provide a technical basis for residence time	XI. SZ FLOW AND TRANSPORT
RT.2.08	Uncertainty distribution of flow path lengths in the alluvium	XI. SZ FLOW AND TRANSPORT

Technical Basis Document (TBDoc) and Supporting KTIs		KTI Response Groups from 6/23/03 letter
RT.3.03	Uncertainty distribution of flow path lengths in the tuff	XI. SZ FLOW AND TRANSPORT
USFIC.5.04	Justify the uncertainty distribution of flow path lengths in the alluvium	XI. SZ FLOW AND TRANSPORT
RT.1.05	How transport parameters were derived consistent with NUREG-1563	XI. SZ FLOW AND TRANSPORT
RT.2.01	Justification for the range of effective porosity in alluvium	XI. SZ FLOW AND TRANSPORT
RT.2.03.AIN-1	Plan for alluvial testing in ATC and Nye County Drilling Program	XI. SZ FLOW AND TRANSPORT
RT.2.10	How transport parameters were derived consistent with NUREG-1563	XI. SZ FLOW AND TRANSPORT
RT.2.02	Spatial variability of parameters affecting radionuclide transport in alluvium	XI. SZ FLOW AND TRANSPORT
TSPAI.3.32	Uncertainty in the saturated zone as lack-of-knowledge, rather than sample variability	XI. SZ FLOW AND TRANSPORT
TSPAI.4.02	Representation of distribution coefficients (Kds) in the performance assessment	XI. SZ FLOW AND TRANSPORT
RT.1.04	Sensitivity studies on Kd for plutonium, uranium, and protactinium	X. UZ TRANSPORT
RT.2.06	Kd experiments on alluvium	XI. SZ FLOW AND TRANSPORT
RT.2.07	Alluvial field and laboratory testing	XI. SZ FLOW AND TRANSPORT
TSPAI.3.31	Effects of temporal changes in saturated zone chemistry on radionuclide concentrations	XI. SZ FLOW AND TRANSPORT
RT.3.08.AIN-1	Justification that microspheres can be used as analogs for colloids	XI. SZ FLOW AND TRANSPORT

Technical Basis Document (TBDoc) and Supporting KTIs		KTI Response Groups from 6/23/03 letter
Biosphere Transport		
IA.2.11	Surface disturbing activities associated with habits and lifestyles of critical group	XII. BIOSPHERE TRANSPORT
IA.2.14	Effects of deposit thickness on average mass load over the transition period	XII. BIOSPHERE TRANSPORT
IA.2.15	External exposure from HLW-contaminated ash	XII. BIOSPHERE TRANSPORT
TSPAI.3.33	Kd values used for radionuclides in the soil in Amargosa valley	XII. BIOSPHERE TRANSPORT
TSPAI.3.34	Radionuclide or element specific biosphere parameters important to BDCF calculations	XII. BIOSPHERE TRANSPORT
TSPAI.3.35	Justification that assumed crop interception fraction is appropriate for all radionuclides considered	XII. BIOSPHERE TRANSPORT
TSPAI.3.36	Methodology used to incorporate the uncertainty in soil leaching factors into TSPA	XII. BIOSPHERE TRANSPORT
Volcanic Events		
IA.1.02.AIN-1 (Note 2)	Examine new aeromagnetic data for potential buried igneous features	XIII. VOLCANIC EVENTS
IA.2.03.AIN-1	Likely range of tephra volumes from YMP Region volcanos	XIII. VOLCANIC EVENTS
IA.2.09.AIN-1	Wind speeds for the various heights of eruption columns being modeled	XIII. VOLCANIC EVENTS
IA.2.18	Effects of engineered repository structures on magma flow processes	XIII. VOLCANIC EVENTS

Technical Basis Document (TBDoc) and Supporting KTIs		KTI Response Groups from 6/23/03 letter
IA.2.19	Waste package response to thermal and mechanical stresses from exposure to basaltic magma	XIII. VOLCANIC EVENTS
IA.2.20	Potential for basaltic magma to incorporate HLW	XIII. VOLCANIC EVENTS
IA.2.17	Effects on dose of eolian and fluvial remobilization	XIII. VOLCANIC EVENTS
Low Probability Seismic Events		
CLST.3.10	Rockfall and vibratory loading effects on the mechanical failure of cladding	XIV. LOW PROB SEISMIC
TSPAI.3.06	Methodology used to implement the effects of seismic effects on cladding	XIV. LOW PROB SEISMIC
RDTME.2.01	Provide Topical Report 3, Preclosure Seismic Design Inputs for a Geologic Repository	XIV. LOW PROB SEISMIC
RDTME.2.02	Provide draft final seismic design inputs for LA and Seismic Topical Report 3	XIV. LOW PROB SEISMIC
RDTME.3.03	Provide the Seismic Design Inputs AMR and the Preclosure Seismic Design Inputs	XIV. LOW PROB SEISMIC
SDS.2.01.AIN-1	Provide clear documentation of the expert elicitation process	XIV. LOW PROB SEISMIC
SDS.2.02	Udate FEPs; Disruptive Events AMR, Seismic Design Inputs, Seismic Topical Report	XIV. LOW PROB SEISMIC
SDS.2.04.AIN-1	Document seismic fragility curves and seismic risk analysis	XIV. LOW PROB SEISMIC
Barrier Capability/Total System Performance Assessment & Integration		
TSPAI.1.02	Documentation of barrier capabilities and the corresponding technical bases	BC/TSPAI

Technical Basis Document (TBDoc) and Supporting KTIs		KTI Response Groups from 6/23/03 letter
TSPAI.3.37	Justify sampling and correlation methods	
TSPAI.3.38.AIN-1	Develop guidance in the model abstraction process	BS/TSPAI
TSPAI.3.39.AIN-1	Document the simplifications used for abstractions	BC/TSPAI
TSPAI.3.41.AIN-1	Support for mathematical representation of data uncertainty in the TSPA	BC/TSPAI
TSPAI.4.01.AIN-1	Document methodology us to incorporate alternate conceptual models into TSPA	BC/TSPAI
TSPAI.4.03 & TSPAI 4.03.AIN-1	Demonstrate that the overall results of the TSPA are stable	BC/TSPAI
TSPAI.4.04	Demonstrate that TSPA results are stable with respect to spatial and temporal discretization	BC/TSPAI
TSPAI.4.06	Demonstrate compliance with model confidence criteria	BC/TSPAI
Criticality		
PRE.7.01	Update the Pre-Closure Criticality Analysis Process Report	CRITICALITY
CLST.5.03	Technical basis for screening criticality from the post-closure performance assessment	CRITICALITY
CLST.5.05.AIN-1	Consequences of increased radiolysis due to criticality events.	CRITICALITY
CLST.5.04 & CLST.5.04.AIN-1	Provide the list of (geochemistry) validation reports and their schedules	CRITICALITY
ENFE.5.03 & ENFE.5.03.AIN-1	Provide list of (geochemistry) validation reports and schedules for external criticality; provide validation approach (geochemistry) and justification that validation independent of models/calibration.	CRITICALITY
RT.4.03 & RT.4.03.AIN-1	Provide list of (geochemistry) validation reports and their schedules for external criticality	CRITICALITY

Technical Basis Document (TBDoc) and Supporting KTIs		KTI Response Groups from 6/23/03 letter
Features, Events, and Processes		
TSPAI.2.01	Provide clarification of the screening arguments	FEP
TSPAI.2.02	Provide the technical basis for the screening arguments	FEP
TSPAI.2.03	Add the FEPs highlighted in Attachment 2	FEP
TSPAI.2.04	Provide a clarification of the description of the primary FEPs	FEP
TSPAI.2.07	Provide results of the implementation of the Enhanced FEP Plan.	FEP
UNGROUPED		
USFIC.4.02	Seepage - film flow	UNGROUPED
USFIC.4.03	Seepage - tunnel irregularities	UNGROUPED
TSPAI.2.05.AIN-1	FEPs (submitted to DOE)	UNGROUPED
TSPAI.2.06.AIN-1	FEPs (submitted to DOE)	UNGROUPED
PRE 6.01 AIN-1	QA Procedures - update procedure AP-2.22Q.	UNGROUPED
ENFE.1.07.AIN-1	Model of matrix fracture interaction precipitation effects (e.g., coring)	III. WATER SEEPING INTO DRIFTS
ENFE.4.02	Drift-Scale Coupled Processes (DST and THC Seepage) Models AMR, ReV. IN-DRIFT In-Drift Chemical Environment01 & 02	III. WATER SEEPING INTO DRIFTS
PRE.3.01	Aircraft hazards	UNGROUPED

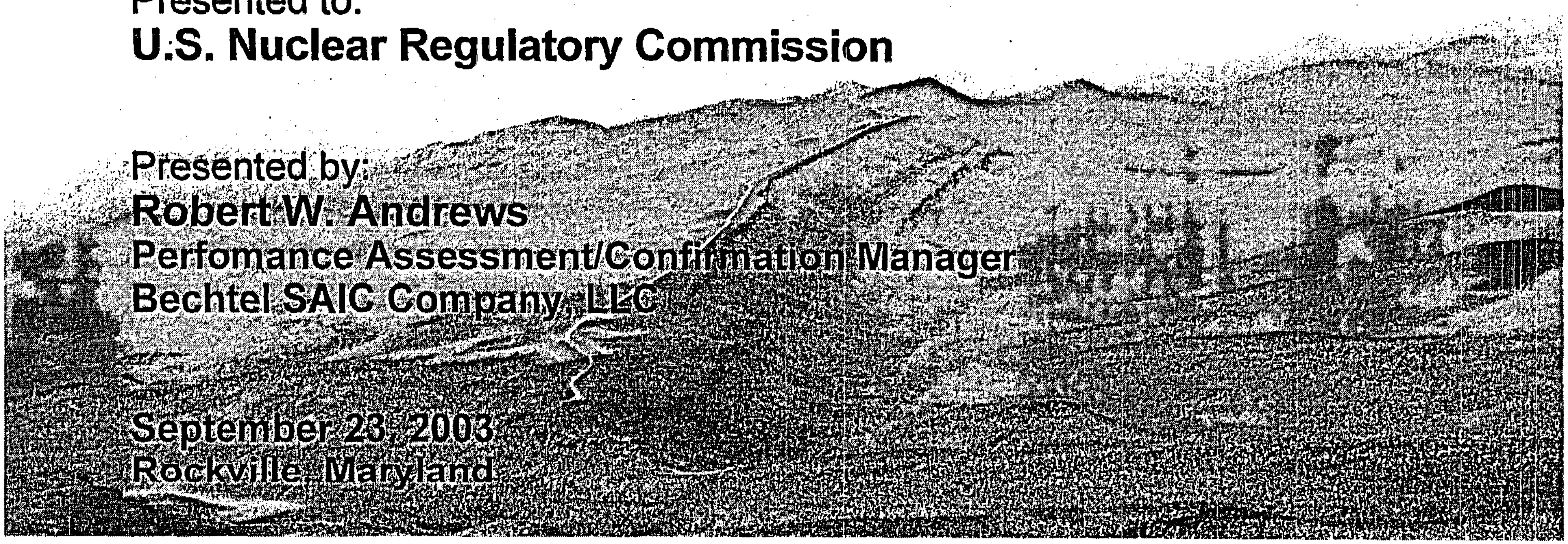
Technical Basis Document (TBDoc) and Supporting KTIs		KTI Response Groups from 6/23/03 letter
PRE.7.02	Waste package finite element analysis based numerical simulations	IV. MECH DEGRAD
GEN.1.01 (Note 1)	General Agreement	UNGROUPED
RDTME.3.14	Provide the results of the ventilation modeling (Multi-Flux code) and technical bases	IV. MECH DEGRAD
RDTME.3.17	Technical basis for effective maximum rock size	UNGROUPED
ENFE.2.18	Provide 18 AMRs according to schedule	FEP
RDTME.3.07	Effect of sustained loading on intact rock strength	III. WATER SEEPING INTO DRIFTS

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

YUCCA MOUNTAIN PROJECT

Development of Technical Basis Documents for Postclosure Performance Assessment

Presented to:
U.S. Nuclear Regulatory Commission



Presented by:
Robert W. Andrews
Perfomance Assessment/Confirmation Manager
Bechtel SAIC Company, LLC

September 23, 2003
Rockville, Maryland

Outline

- Development of Technical Bases for Postclosure Performance Assessment
- Correlation of Technical Basis Documents to Key Technical Issues (KTIs) and Yucca Mountain Review Plan (YMRP) Model Abstraction groups
- Scope and Content of Technical Basis Documents
- Summary and Conclusions

Development of Technical Bases

- **Perform scientific/engineering work (design, testing, model refinement and validation, and analyses)**
  - Focus on addressing NRC/DOE Key Technical Issue (KTI) agreements
- **Document scientific/engineering work in technical products**
  - Scientific notebooks/data analysis
  - Analysis/model reports
  - Calculations/drawings
- **Utilize scientific/engineering work to assess postclosure performance**
- **Abstract work from technical products into integrated Technical Basis Documents**
  - Document technical bases consistent with NRC's YMRP

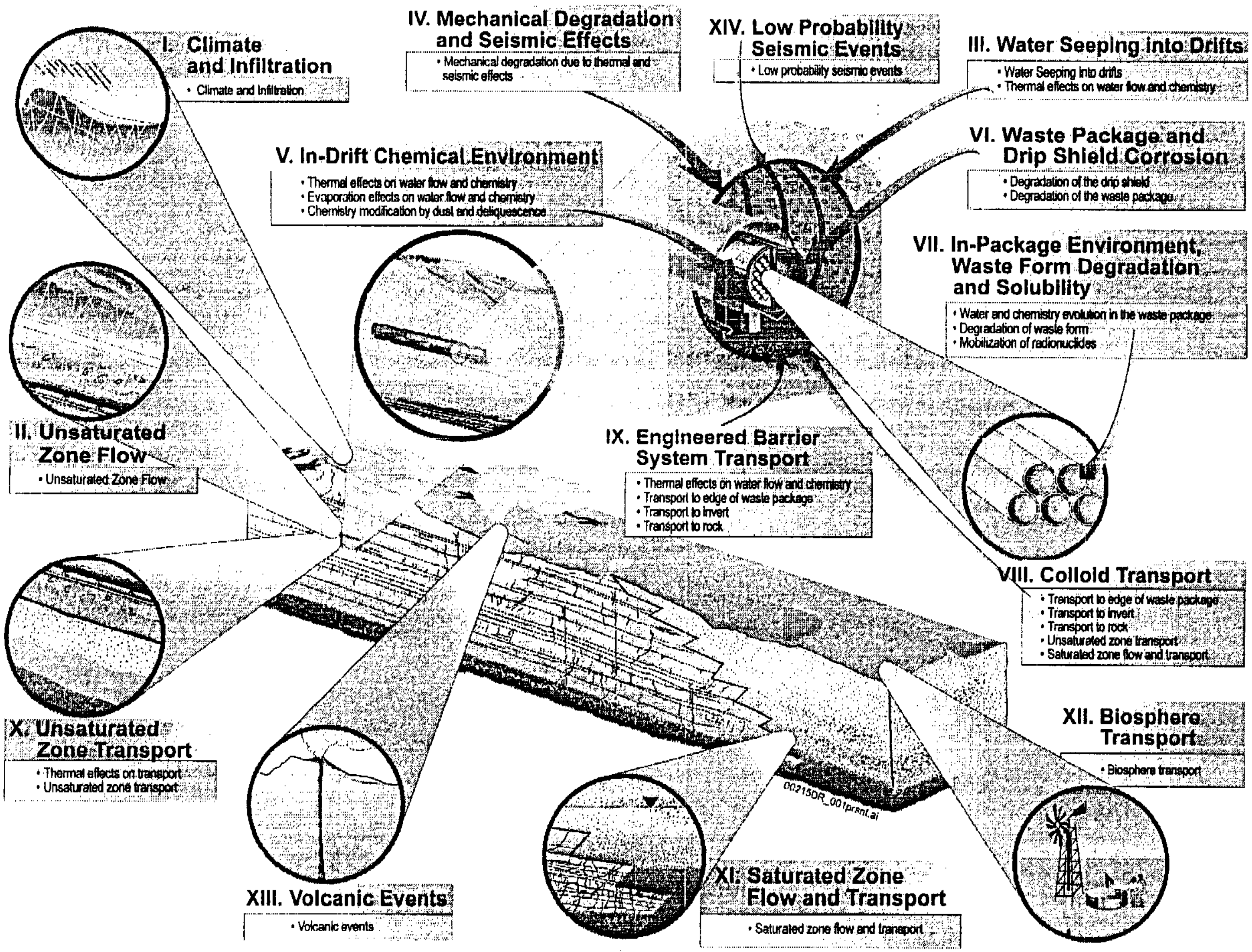
Methods Considered to Organize Development of Technical Basis Documents

- Scale
- Process
- State variables
  - Temperature, pressure, chemistry, stress, hydrology (flux and saturation), radionuclide concentration
- Time
- Space
- Features
  - Sequential features identified by following the path of water and radionuclides through the system

Mapping of Process and State Variables at Different Scales – Nominal Performance

Scale	Key Processes	Key State Variables
Repository scale	Climate and infiltration Unsaturated zone flow	Water flux, saturation
Drift scale	Seepage and thermal effects Mechanical degradation Chemistry and thermal effects	Water flux, saturation, temperature, stress, chemistry
Waste package scale	Chemistry evolution in drifts Drip shield degradation Waste package degradation	Water flux, temperature, stress, chemistry
Waste form scale	Water and chemistry evolution in the waste package Degradation of waste form Mobilization of radionuclides Transport to edge of waste package	Water flux, temperature, chemistry, radionuclide concentration
Drift scale	Transport to invert Transport to rock Thermal effects on transport	Water flux, saturation, temperature, chemistry, radionuclide concentration
Repository scale	Unsaturated zone transport	Water flux, chemistry, radionuclide concentration
Site scale	Saturated zone flow and transport Biosphere transport	Water flux, chemistry, radionuclide concentration

Fourteen Technical Basis Documents



Fourteen Technical Basis Documents
(and Related Processes)

I. Climate and infiltration

II. Unsaturated zone flow

III. Water seeping into drifts
- Water seeping into drifts
- Thermal effects on water flow

IV. Mechanical degradation and seismic effects

V. In-drift chemical environment
- Thermal effects on water flow and chemistry
- Evaporation effects on in-drift water flow and chemistry
- Chemistry modification by dust and deliquescence

VI. Waste package and drip shield corrosion
- Degradation of the drip shield
- Degradation of the waste package

VII. In-package environment, waste form degradation and solubility
- Water and chemistry evolution in the waste package
- Degradation of waste form
- Mobilization of radionuclides

VIII. Colloid transport
- Mobilization of radionuclides
- Transport to edge of waste package
- Transport to invert
- Transport to rock
- Unsaturated zone transport
- Saturated zone flow and transport

IX. Engineered barrier system transport
- Thermal effects on water flow and chemistry
- Transport to edge of waste package
- Transport to invert
- Transport to rock

X. Unsaturated zone transport
- Thermal effects on transport
- Unsaturated zone transport

XI. Saturated zone flow and transport

XII. Biosphere transport

XIII. Volcanic events

XIV. Low probability seismic events

Correlation of U.S. Nuclear Regulatory Commission Key Technical Issues with Fourteen Technical Basis Documents

NRC Key Technical Issue	Technical Basis Documents
Unsaturated and saturated flow under isothermal conditions (USFIC)	I. Climate and Infiltration II. Unsaturated zone flow III. Water Seeping into drifts XI. Saturated zone flow and transport
Thermal Effects on Flow (TEF)	II. Unsaturated zone flow III. Water seeping into drifts IV. Mechanical degradation and seismic effects VII. In-package environment, waste form degradation and solubility
Repository Design and Thermal Mechanical Effects (RDTME)	IV. Mechanical degradation and seismic effects
Engineered Near Field Environment (ENFE)	III. Water Seeping into drifts IV. Mechanical degradation and seismic effects V. In-drift chemical environment VI. Waste package and drip shield corrosion VII. In-package environment, waste form degradation and solubility IX. Engineered barrier system transport
Container Life and Source Term (CLST)	IV. Mechanical degradation and seismic effects V. In-drift chemical environment VI. Waste package and drip shield corrosion VII. In-package environment, waste form degradation and solubility
Radionuclide Transport (RT)	IX. Engineered barrier system transport X. Unsaturated zone transport XI. Saturated zone flow and transport XII. Biosphere transport
Igneous Activity (IA)	XII. Biosphere transport XIII. Volcanic events
Structural Deformation and Seismicity (SDS)	IV. Mechanical degradation and seismic events XIV. Low probability seismic effects
Total System Performance Assessment and Integration (TSPAI)	All, especially related to TSPAI 2.01 and 2.02

Correlation of Yucca Mountain Review Plan Abstraction Groups with Fourteen Technical Basis Documents

YMRP Abstraction Group	Technical Basis Documents
1. Degradation of Engineered Barriers	VI. *Waste package and drip shield corrosion*
2. Mechanical Disruption of Engineered Barriers	IV. Mechanical degradation and seismic events XIV. Low Probability seismic effects
3. Quantity And Chemistry of Water Contacting Waste Packages and Waste Forms	III. Water seeping into drifts V. In-Drift chemical environments VII. In-package environment
4. Radionuclide Release Rates and Solubility Limits	VII. Waste form degradation and solubility VIII. Colloids IX. Engineered barrier system transport
5. Climate and Infiltration	I. Climate and infiltration
6. Flow Paths in the Unsaturated Zone	II. Unsaturated zone flow
7. Radionuclide Transport in the Unsaturated Zone	X. Unsaturated zone transport
8. Flow Paths in the Saturated Zone	XI. Saturated zone flow and transport
9. Radionuclide Transport in the Saturated Zone	XI. Saturated zone flow and transport (see above)
10. Volcanic Disruption of Waste Packages	XIII. Volcanic disruptive events
11. Airborne Transport of Radionuclides	XIII. Volcanic disruptive events (see above)
12. Concentration of Radionuclides in Groundwater	XI. Saturated zone flow and transport (see above)
13. Redistribution of Radionuclides in Soil	XII. Biosphere transport (see below)
14. Biosphere Characteristics	XII. Biosphere transport

Scope of Technical Basis Documents

- Summarize key processes and, as appropriate, relevant features and events for the 14 components of the postclosure performance
- Describe relevance of processes to performance assessment
- Summarize key information used as basis for conceptual understanding
- Present models used to support development of abstractions used in performance assessment
- Summarize information used as a basis for parameters within models
- Summarize key results of model abstractions
- Introduce appendices where individual (or grouped) KTI responses are presented

Content of Technical Basis Documents

- Introduction to processes considered and relationship to performance and other processes
- Description of processes and related models
- Summary of information forming the basis for process and model understanding
- Summary of information forming the basis of parameter development
- Discussion of parameter and model uncertainty
- Summary of model results (e.g., abstractions) relevant to performance assessment

Summary and Conclusions

- The Project is developing a set of Technical Basis Documents that describe the Yucca Mountain repository system components to provide a summary of the analyses (and their basis) to respond to KTI agreements
- The goal of these documents is to provide a clear and transparent summary of the role of each component in the postclosure performance and to respond to related KTI agreements in the context of this summary
- Technical Basis Documents present key information that supports the basis for process models and the parameters developed for model abstraction

Summary and Conclusions
(Continued)

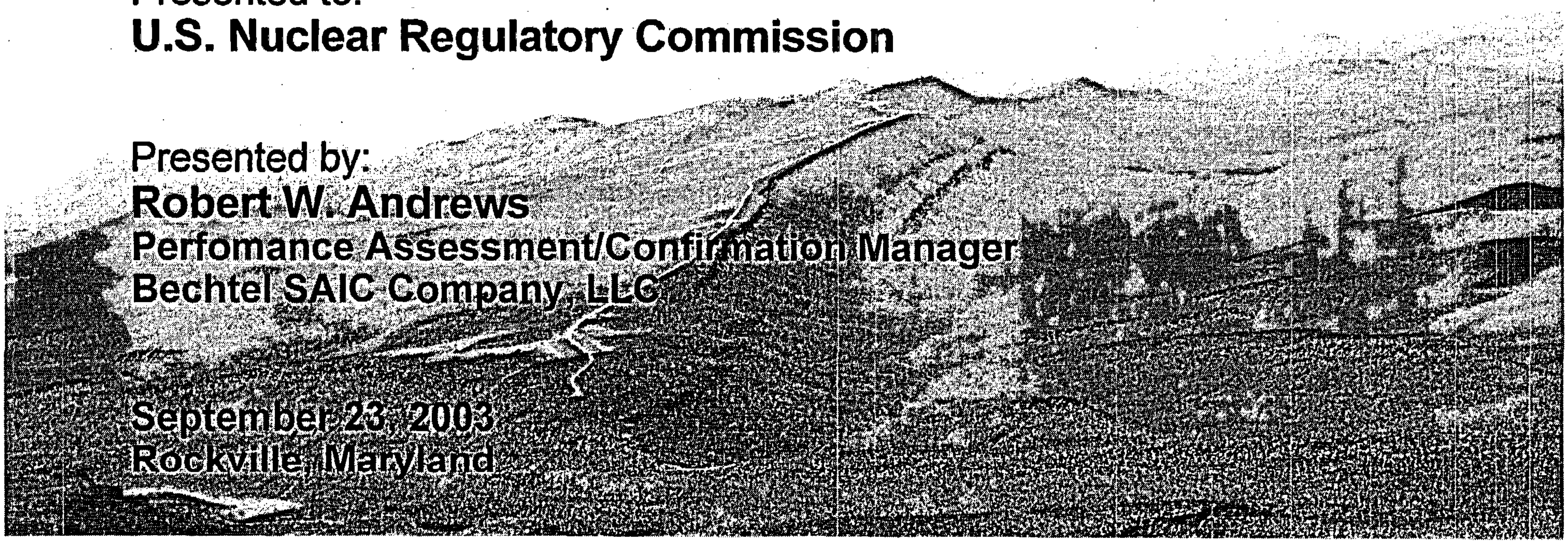
- The Technical Basis Documents are planned to be delivered to NRC over the next 3 to 6 months
  - Biosphere Transport, Saturated Zone Flow and Transport, and Colloid Technical Basis Documents are expected to be delivered to NRC within the next month
  - In-Drift Chemical Environment, Waste Package/Drip Shield Degradation, Seepage, and Igneous Activity are expected to be delivered next

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

YUCCA MOUNTAIN PROJECT

Example Development of Technical Basis Documents for Postclosure Performance Assessment - Saturated Zone Flow and Transport

Presented to:
U.S. Nuclear Regulatory Commission



Presented by:
Robert W. Andrews
Perfomance Assessment/Confirmation Manager
Bechtel SAIC Company, LLC

September 23, 2003
Rockville, Maryland

Outline

- Outline of Saturated Zone Flow and Transport Technical Basis Document
- Key Processes
  - Regional groundwater flow
  - Site-scale groundwater flow
  - Advection, matrix diffusion and dispersion
  - Radionuclide retardation
- Major results
- Summary and Conclusions

Outline of Saturated Zone Flow and Transport Technical Basis Document

1. Introduction
2. Saturated Zone Groundwater Flow Processes
   - 2.1 Introduction
   - 2.2 Regional Groundwater Flow System
   - 2.3 Site-Scale Groundwater Flow System
   - 2.4 Summary
3. Saturated Zone Radionuclide Transport Processes
   - 3.1 Introduction
   - 3.2 Advection, Matrix Diffusion and Dispersion Processes
     - 3.2.1 Fractured Volcanic Tuffs
     - 3.2.2 Alluvium
     - 3.2.3 Corroboration Using Carbon Isotopes
   - 3.3 Radionuclide Sorption Processes
   - 3.4 Site-Scale Radionuclide Transport Model
4. Summary and Conclusions

Outline of Saturated Zone Flow and Transport Technical Basis Document - Appendices

A. HFM-GFM Interface (USFIC 5.10)

B. Hydrostratigraphic Cross Sections (RT 2.09 AIN-1 and USFIC 5.05 AIN-1)

C. Potentiometric Surface and Vertical Gradients (USFIC 5.08 AIN-1)

D. Regional Model and Confidence Building (USFIC 5.02, USFIC 5.12, and USFIC 5.11 AIN-1)

E. Horizontal Anisotropy (USFIC 5.01)

F. Carbon-14 Residence Time (USFIC 5.06)

G. Uncertainty in Flow Path Lengths in Tuff and Alluvium (RT 2.08, RT 3.08, and USFIC 5.04)

H. Transport Properties (RT 1.05, RT 2.01, RT 2.10, and RT 2.03 AIN-1)

I. Spatial Variability of Parameters (RT 2.02, TSPAI 3.32, and TSPAI 4.02)

J. Kinetic Effects on the Transport Model (RT 1.04)

K. K_D in the Alluvium (RT 2.06, RT 2.07, and GEN 1.01 #41 and #102)

L. Temporal Change in Hydrochemistry (TSPAI 3.31)

M. Microspheres as Analogs (RT 3.08 AIN-1 and GEN 1.01 #45)

Key References Used to Support Saturated Zone Flow and Transport Technical Basis Document

D'Agnese, F.A., O'Brien, G.M., Faunt, C.C., Belcher, W.R., and SanJuan, C., 2002. *A Three-Dimensional Numerical Model of Predevelopment Conditions in the Death Valley Regional Ground-Water Flow System, Nevada and California.* Water-Resources Investigations Report 02-4102.

USGS, 2001. *Water-Level Data Analysis for the Saturated Zone Site-Scale Flow and Transport Model.* ANL-NBS-HS-000034, Rev 00, ICN 01.

Hevesi, J.A., Flint, A.L., and Flint, L.E., 2002. *Preliminary Estimates of Spatially Distributed Net Infiltration and Recharge for the Death Valley Region, Nevada-California.* Water-Resources Investigation Report 02-4010.

Analyses and Model Reports (in development):

Saturated Zone In-situ Testing (Reimus, P. and Umari, M.J.)

Geochemical and Isotopic Constraints on Groundwater Flow Directions and Magnitudes, Mixing and Recharge at Yucca Mountain (Kwickles, E. and Robeck, R.)

Site-Scale Saturated Zone Flow Model (Eddebbarh, A.A. and Zyvoloski, G.)

Site-Scale Saturated Zone Transport Model (Kelkar, R. and Robinson, B.)

Saturated Zone Colloid Transport Model (Viswanathan, H.)

Saturated Zone Flow and Transport Abstractions (Arnold, B.W. and Kuzio, S.)

Saturated Zone Flow and Transport Technical Basis Document - Chapter 2

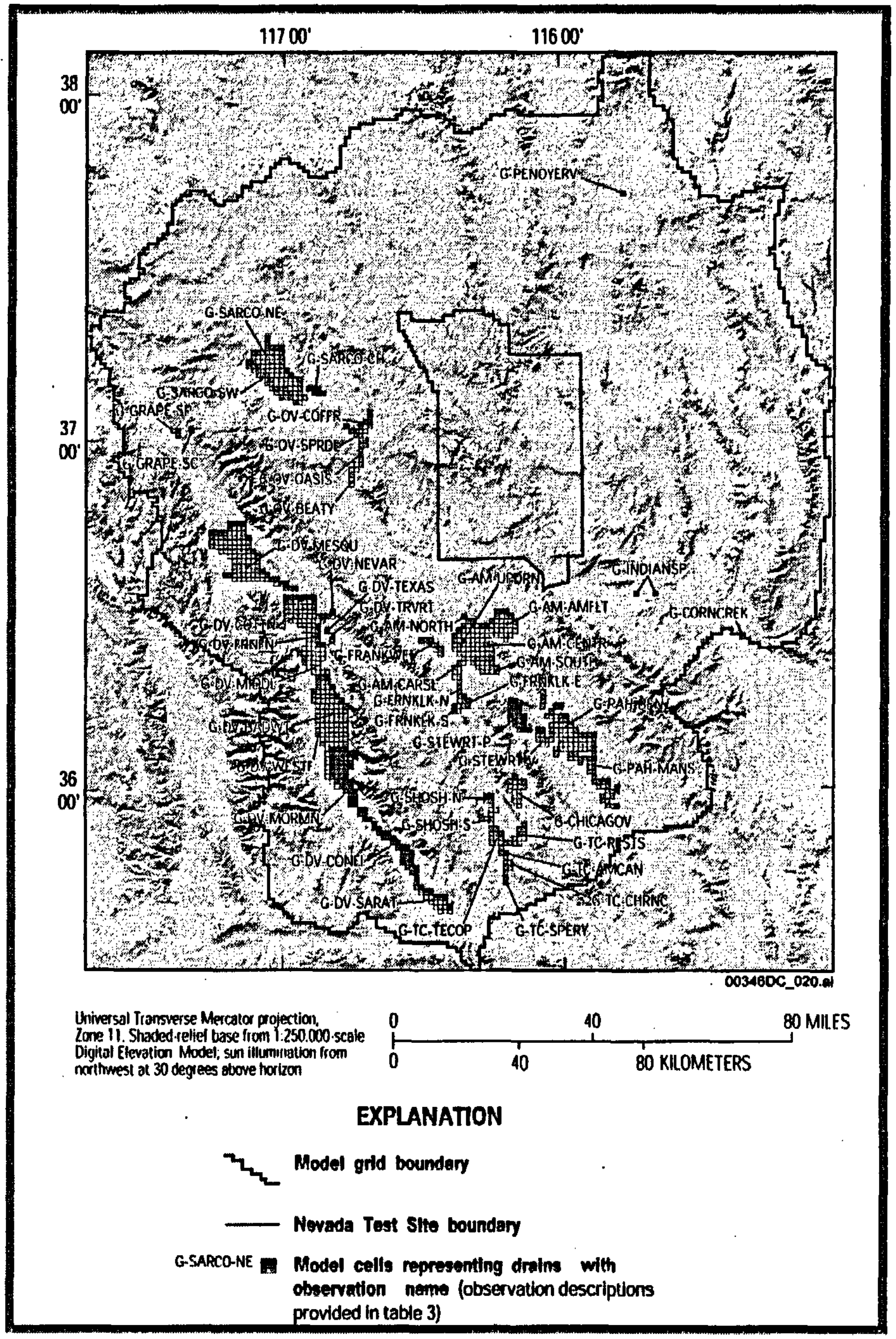
2.2 Regional Groundwater Flow System

Summarize recent U.S. Geological Survey (USGS) regional recharge and discharge information

Summarize regional geochemistry interpretation and basis for general flow paths

Summarize 2002 USGS regional model and basis for general flow paths

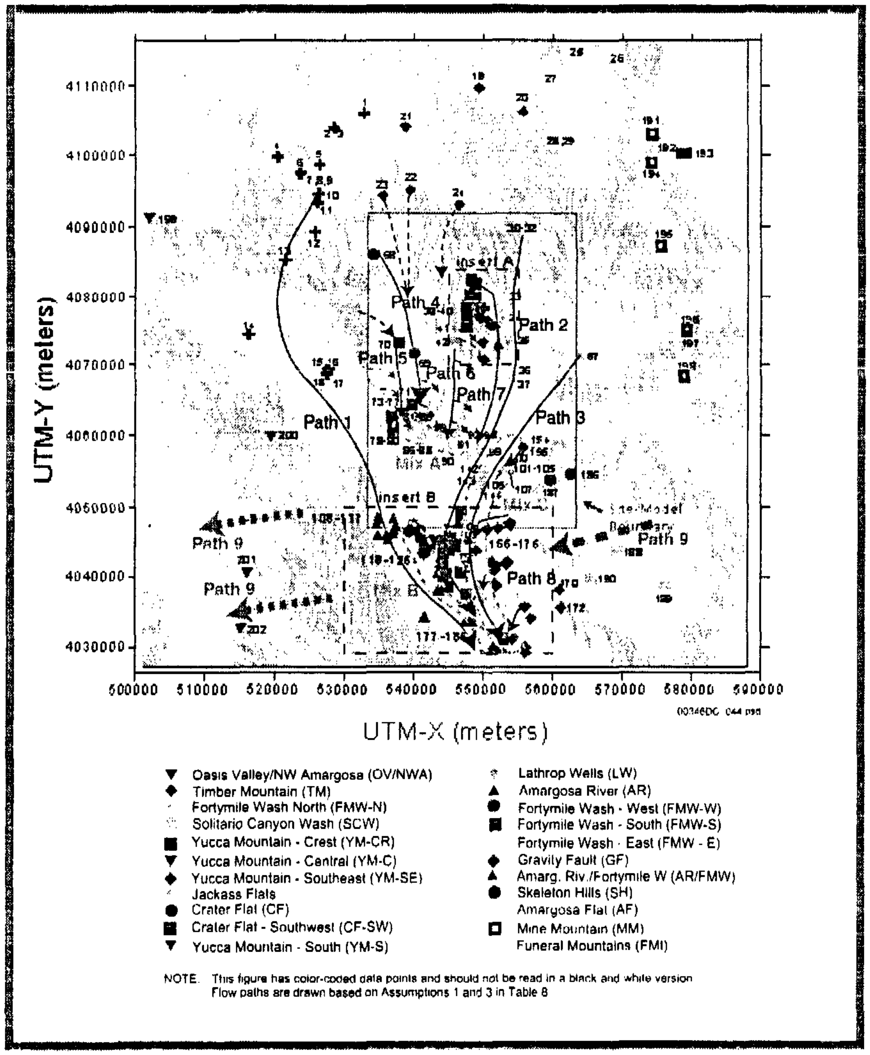
NOTE: Additional details presented in Appendix D in response to Key Technical Issue (KTI) agreements USFIC 5.02, USFIC 5.12, and USFIC 5.11 AIN-1



Discharge Locations in Death Valley Regional Flow System

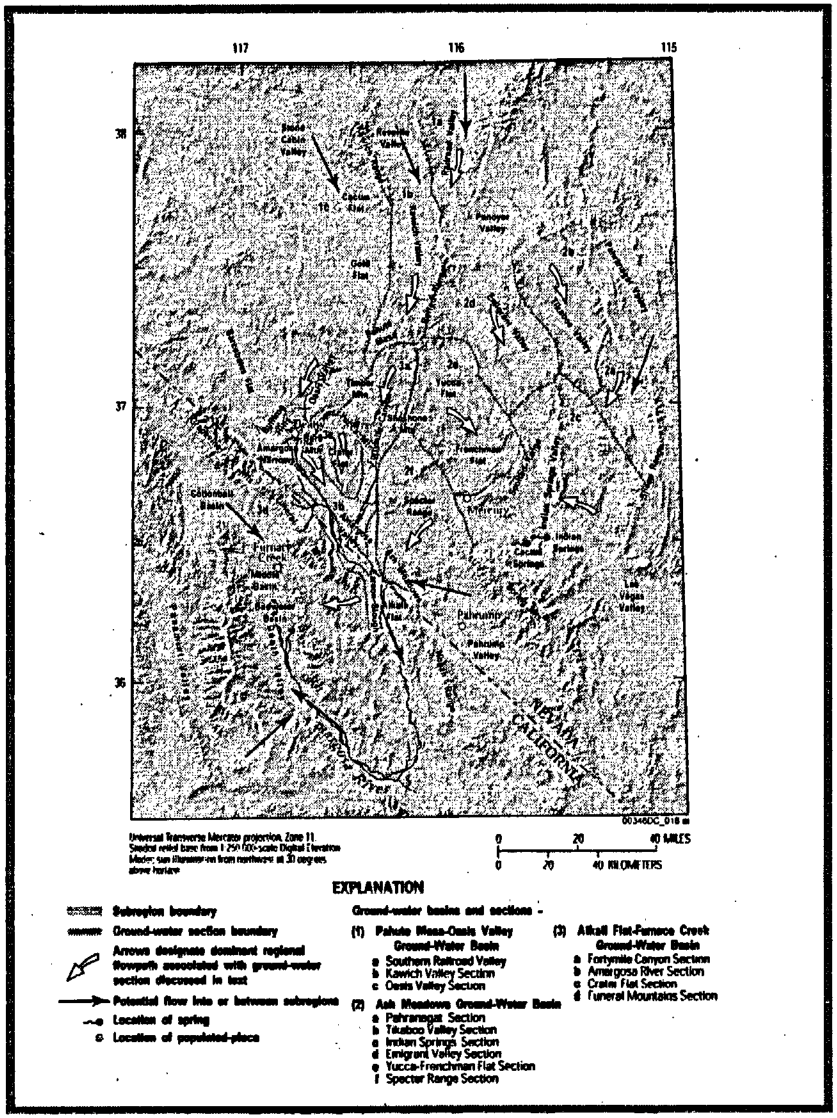
- **Natural groundwater discharge occurs at topographic lows**
- **Significant discharge occurs from carbonate springs and evapotranspiration from shallow groundwater at playas**

Geochemistry Signatures and Inferred Flow Directions and Mixing in Death Valley Regional Flow System



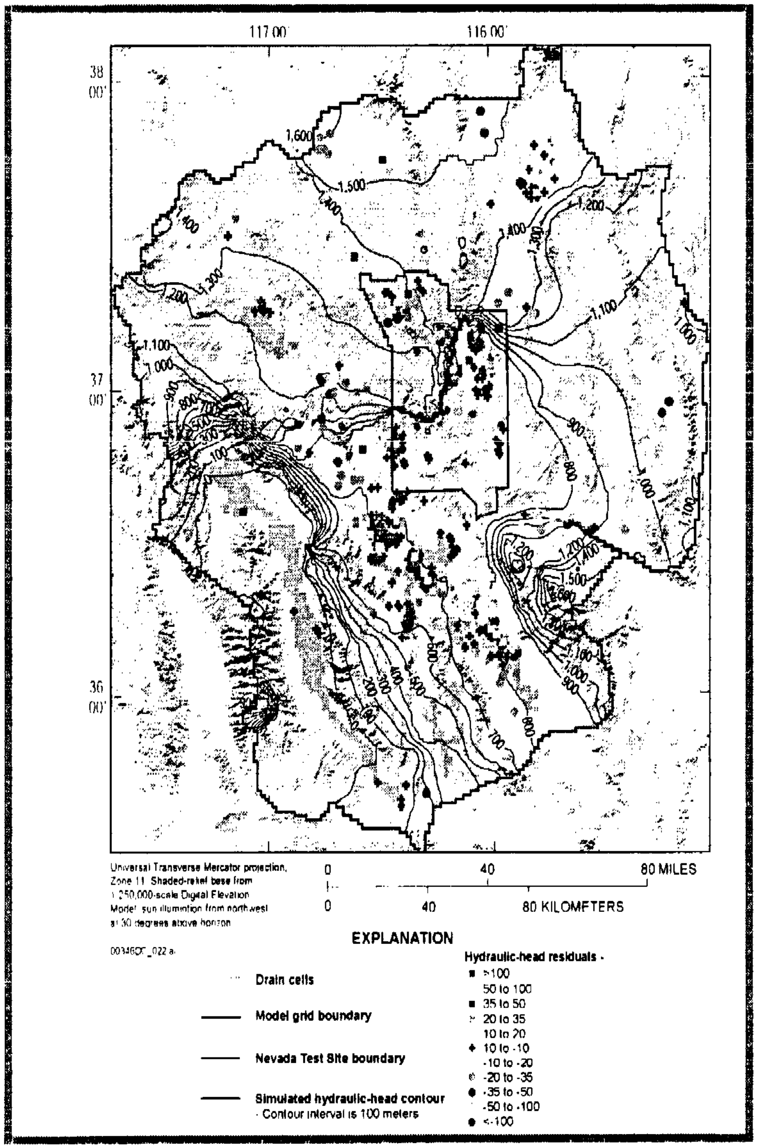
- Dissolved constituents (chloride, sulfate, delta-deuterium, etc) indicative of common trends
- Water types are grouped by similar geochemical signatures along flow paths
- Mixing zones indicate areas where distinct waters mix in larger flow system

General Inferred Flow Directions in Death Valley Regional Flow System



- General flow direction is southerly from recharge areas in north to discharge areas in south
- In vicinity of Yucca Mountain apparent flow direction is southerly

Groundwater Flow Model of the Death Valley Regional Flow System



- Regional model developed by USGS was updated in D'Agnese et al. 2002
- Updated model included refined hydrogeologic framework model and revised recharge and discharge estimates
- Hydraulic head residuals indicate reasonable agreement in vicinity of Yucca Mountain
- Largest differences are in areas of steeper hydraulic gradients

Saturated Zone Flow and Transport Technical Basis Document - Chapter 2

2.3 Site-Scale Groundwater Flow System

Summarize site-scale geology

Summarize site-scale observations (potentiometric surface and hydraulic properties)

Summarize relevance of large scale tests (C-Wells and ATC) to site-scale flow understanding

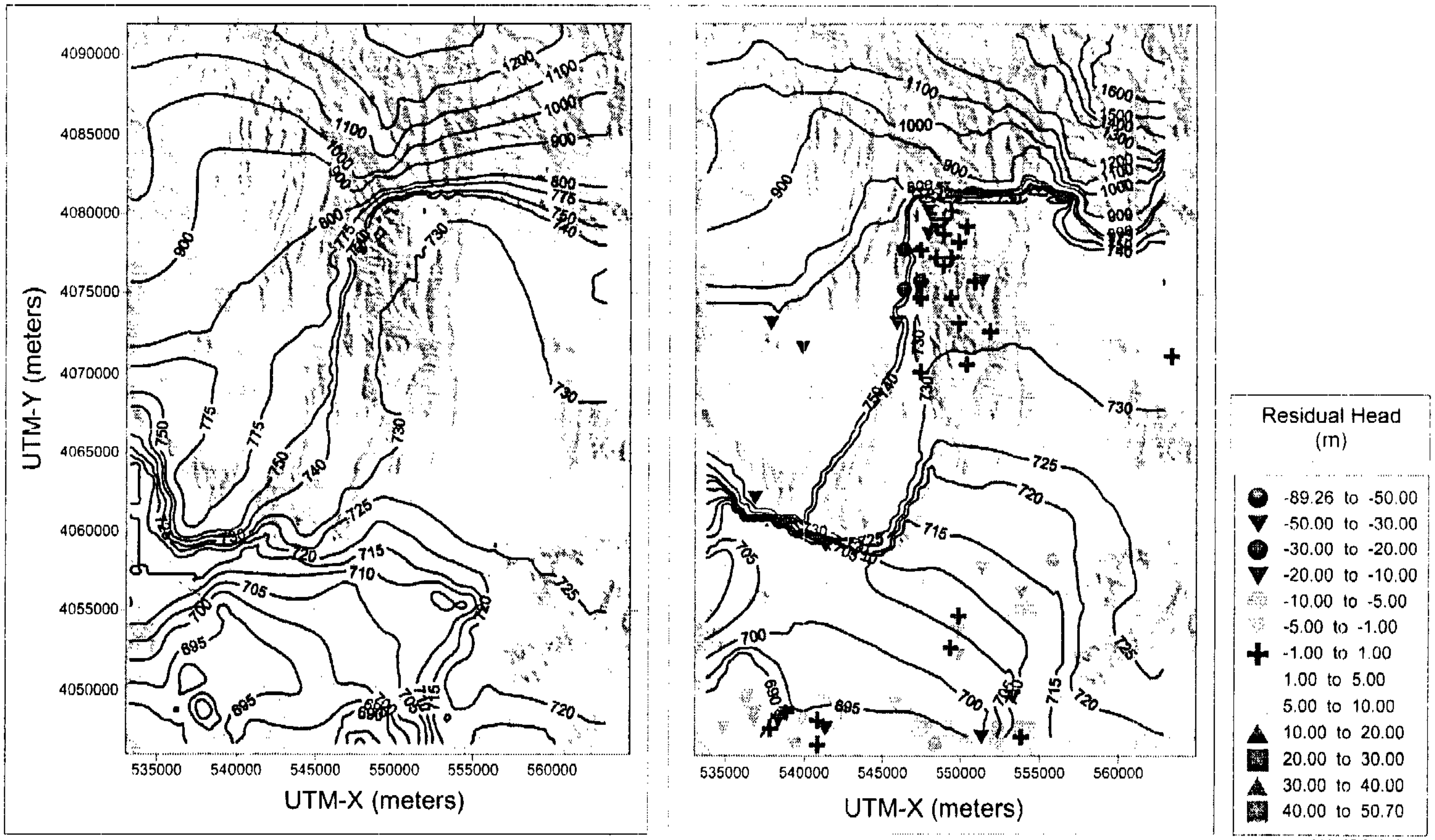
Summarize site-scale flow model

Summarize site-scale flow model results (flow paths, flow rates, travel path in alluvium, uncertainty in flow paths)

Compare flow model results to independent observations (such as tracer tests at ATC)

NOTE: Additional information presented in Appendix G in response to KTI agreements RT 2.08, RT 3.08, and USFIC 5.04)

Site-Scale Modeled and Observed Potentiometric Surfaces

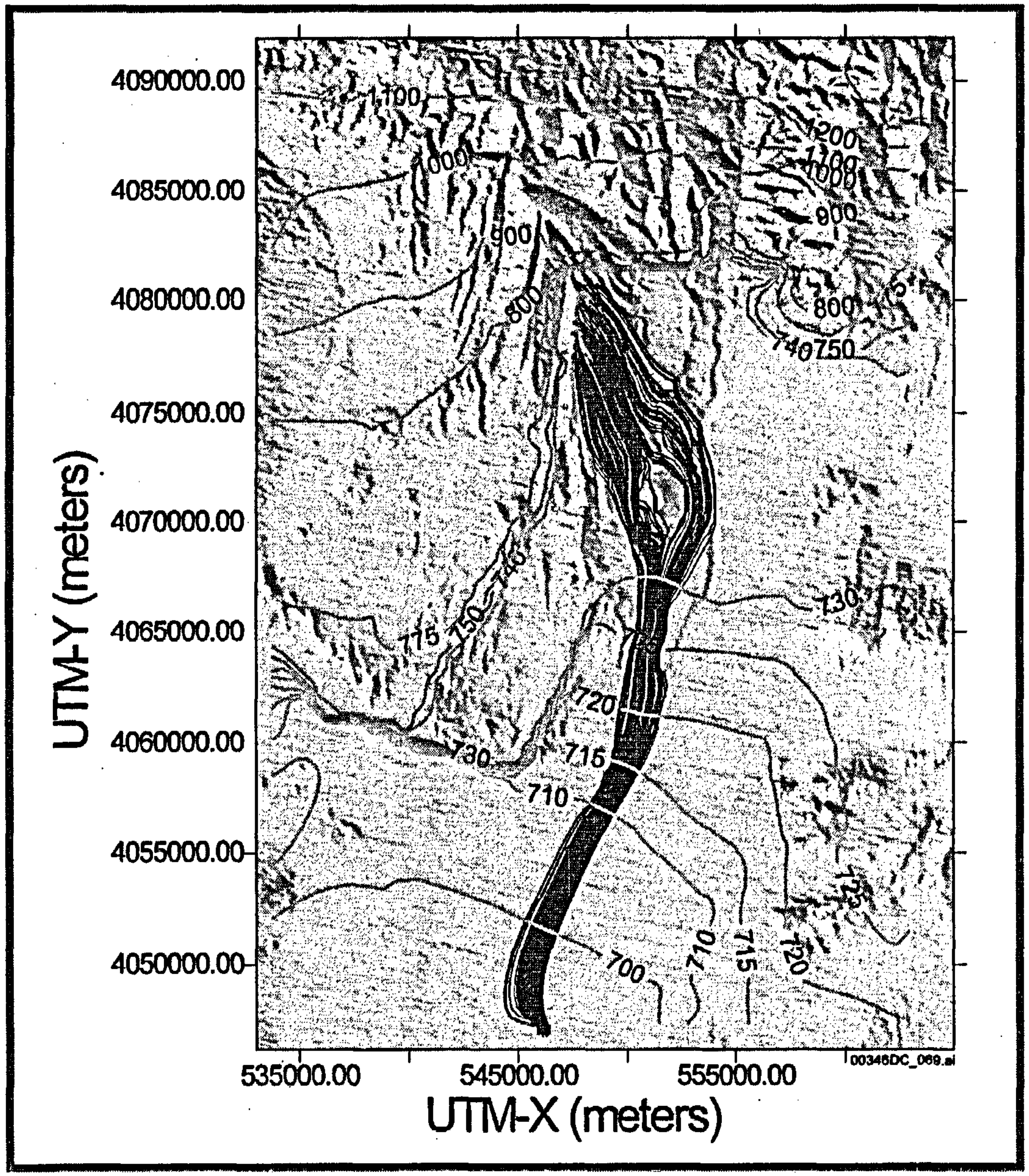


NOTE: Symbols in right panel represent well locations.

00346DC_029.psd

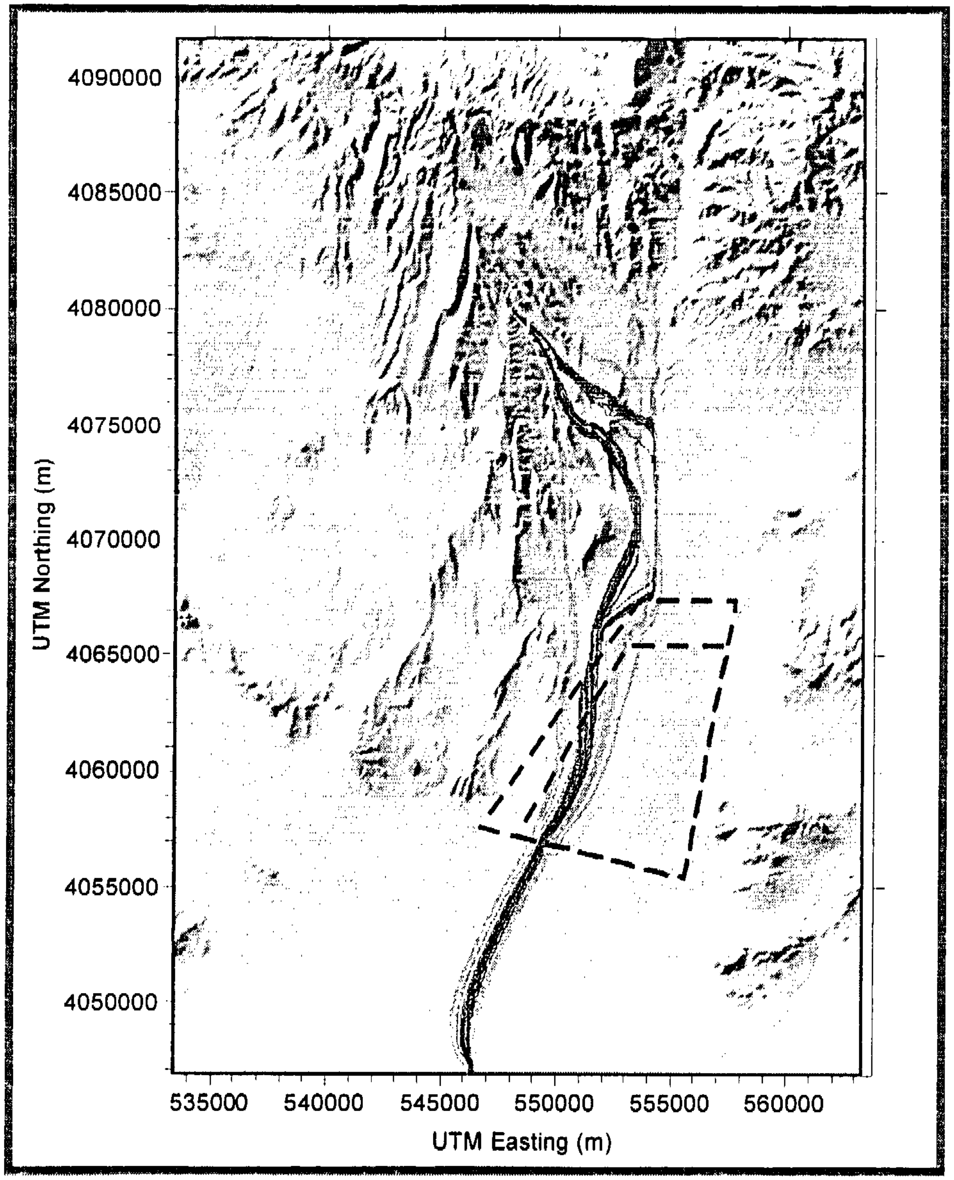
Observed (left) and predicted (right) heads agree with greatest differences in areas of steep hydraulic gradients

Predicted Site-Scale Groundwater Flow Paths



- **Nominal flow path trajectory is generally southeasterly from Yucca Mountain**
- **Flow beneath Fortymile Wash is south-southwesterly**
- **Uncertainty in flow paths due to anisotropy and uncertainty in boundary conditions**
- **Flow rates about 0.7 m/yr under Yucca Mountain increasing to about 2.3 m/yr at 18 km**

Uncertainty in Flow Path Lengths in Alluvium



- Uncertainty in flow path a function of uncertainty in anisotropy in tuff aquifers
  - Green: 0.05
  - Blue: 1.0
  - Red: 20
- Uncertainty in alluvium contact indicated by dashed lines
- Flow path length in alluvium to point of compliance ranges from 1 to 10 km

Saturated Zone Flow and Transport Technical Basis Document - Chapter 3

3.2 Advection, Matrix Diffusion and Dispersion

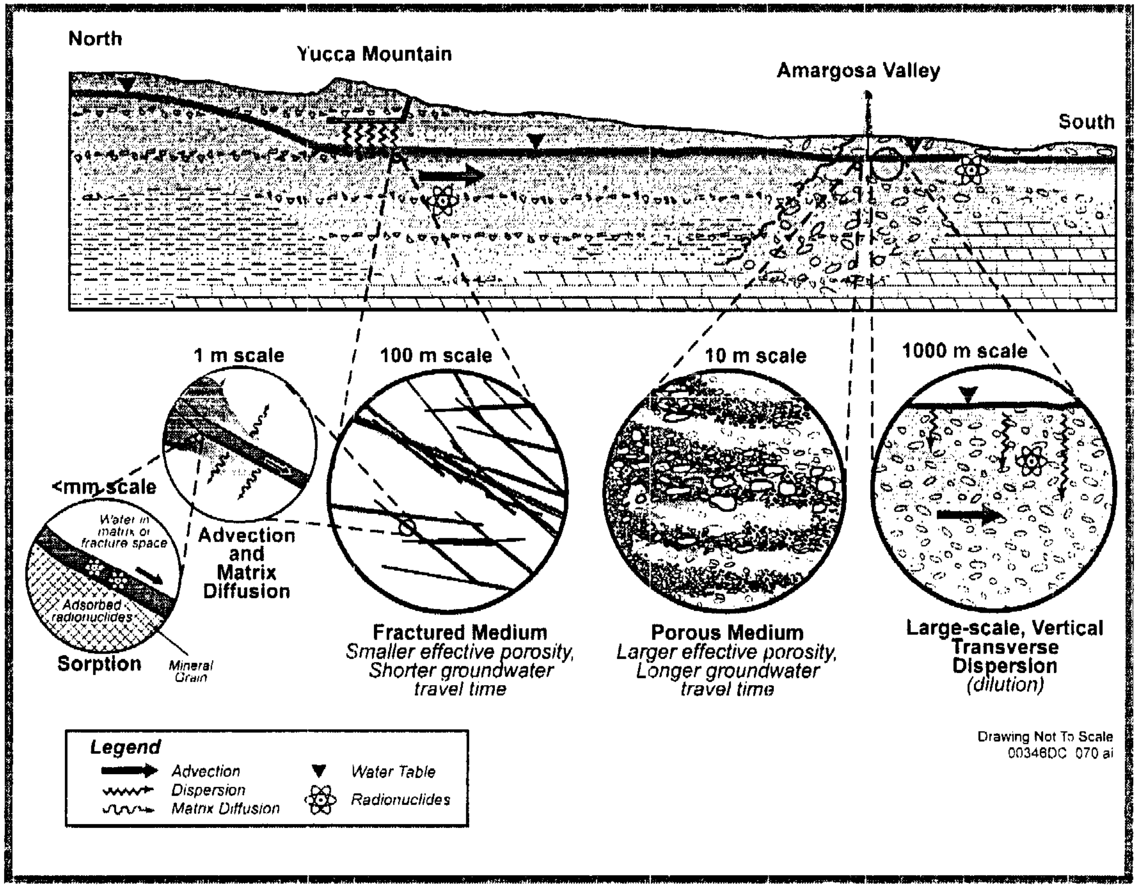
Summarize field data to support parameter development for flowing interval spacing, effective porosity, matrix diffusion and dispersivity

Present uncertainty in above parameters included in evaluation of saturated zone transport

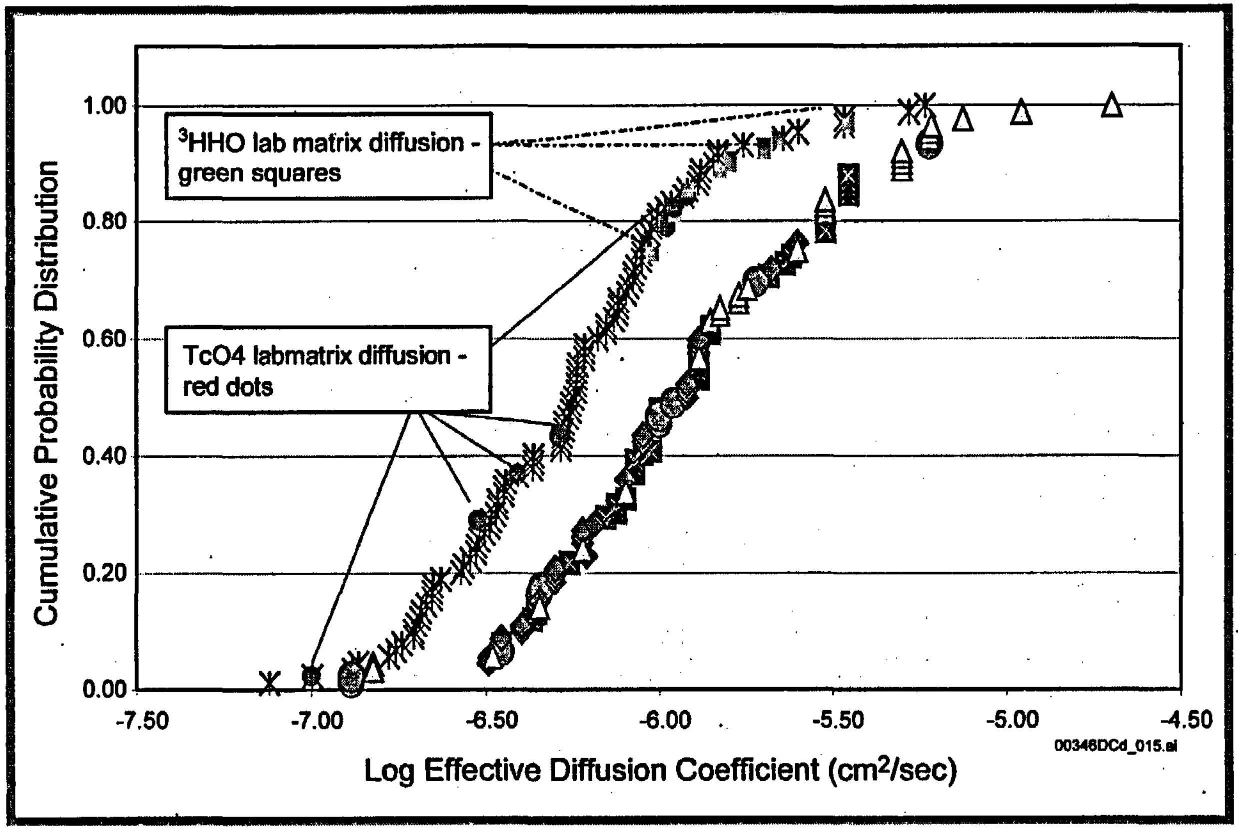
NOTE: Additional details presented in Appendix H in response to KTI agreements RT 1.05, RT 2.01, RT 2.10, GEN 1.01 (#28 and #34) and RT 2.03 AIN-1

Radionuclide Transport Processes

- Transport processes include advection, dispersion, matrix diffusion and retardation
- Advection occurs primarily through fractures in tuff aquifers and through matrix in alluvial aquifer
- Transport characteristics differ between tuff and alluvium



Matrix Diffusion Coefficient Evaluated in Lab and Field Experiments

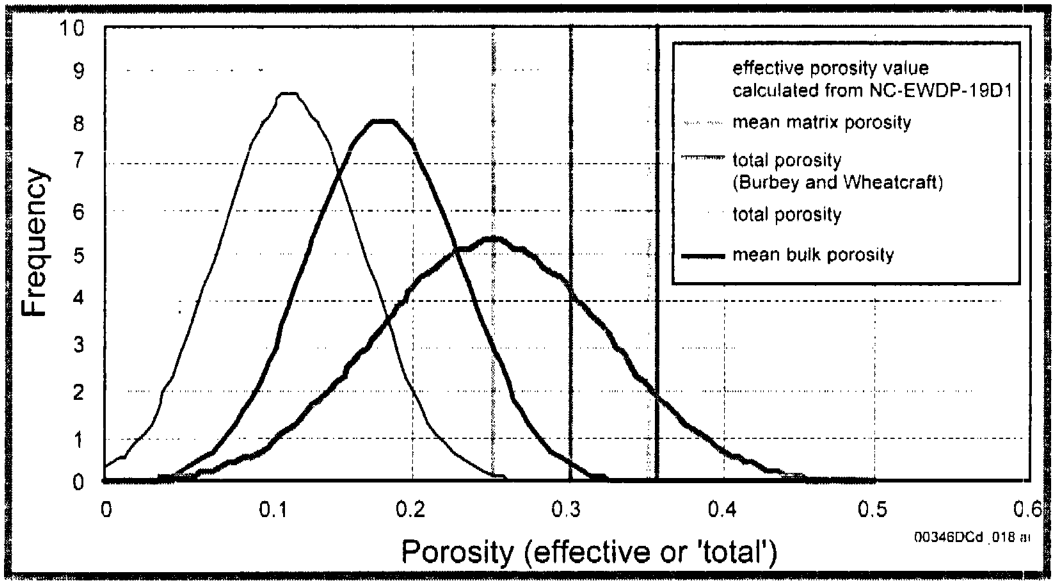


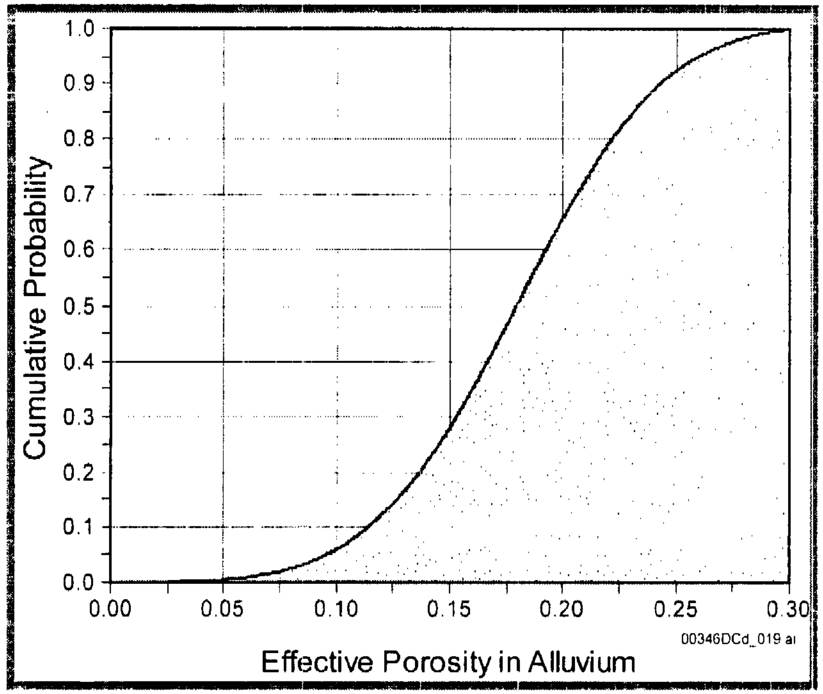
- Matrix diffusion constrained between 10^{-7} and 10^{-5} cm^2/sec
- Lab and field data show similar trends

Left hand curve represents linear relationship based on porosity and permeability from Rundberg et al. 1987 and Triay 1993 data. Right hand curve represents lab and field data (Reimus et al. 2002): Squares ^{3}HHO lab data, diamonds TCO_4 lab data, circles Br^- and PFBA field data.

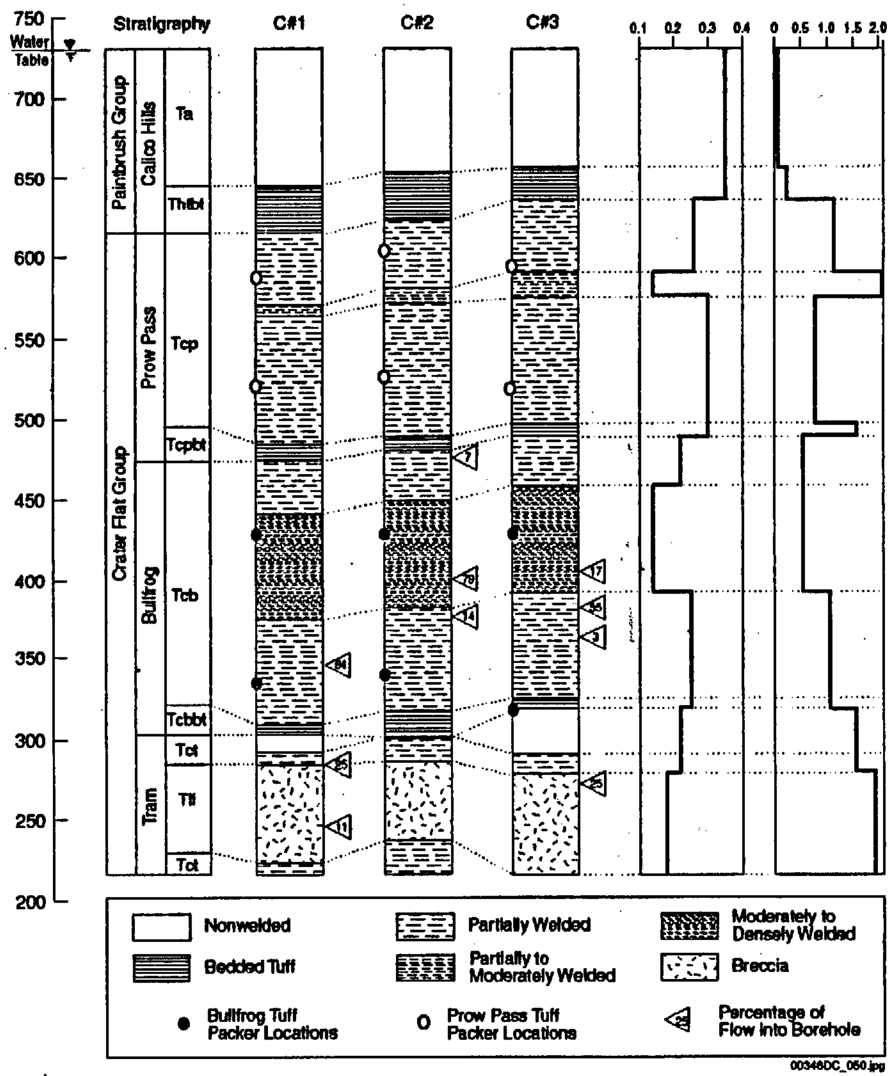
Effective Porosity of Alluvium

- Laboratory and in situ test data (point values) compared to literature estimates (pdf files)
- Uncertainty in parameter included in model abstraction





Flowing Interval Spacing: C-Wells Data and Parameter Uncertainty

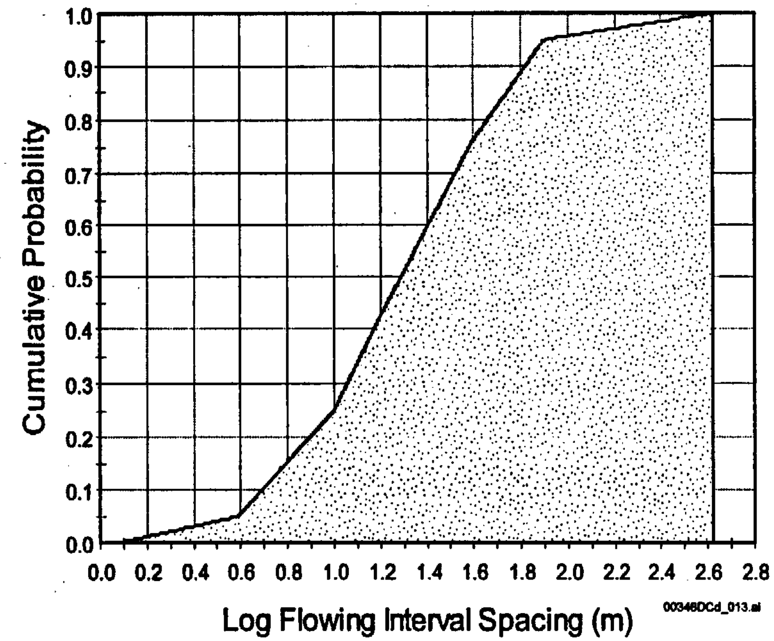


Source: Information derived from Geldon (1993 [101045, WRIR 92-4016 (pp. 35-37, 68-70). Packer locations from Scientific Notebook SN-USGS-SCI-036 [162854], [162856], [162857], [162858].

NOTE: Packer locations indicate intervals in which tracer tests described in this report were conducted. (note that the tracer tests were conducted between UE-25 c#2 and c#3).

Fluid logging data used to develop distribution of flowing interval spacing

NOTE: Well logs represent matrix porosity (left) and fracture spacing (fractures/m) (right)



Saturated Zone Flow and Transport Technical Basis Document - Chapter 3

3.3 Radionuclide Sorption Processes

Summarize field (at C-wells) and lab comparison of sorption

Summarize lab tests of sorption on tuffs

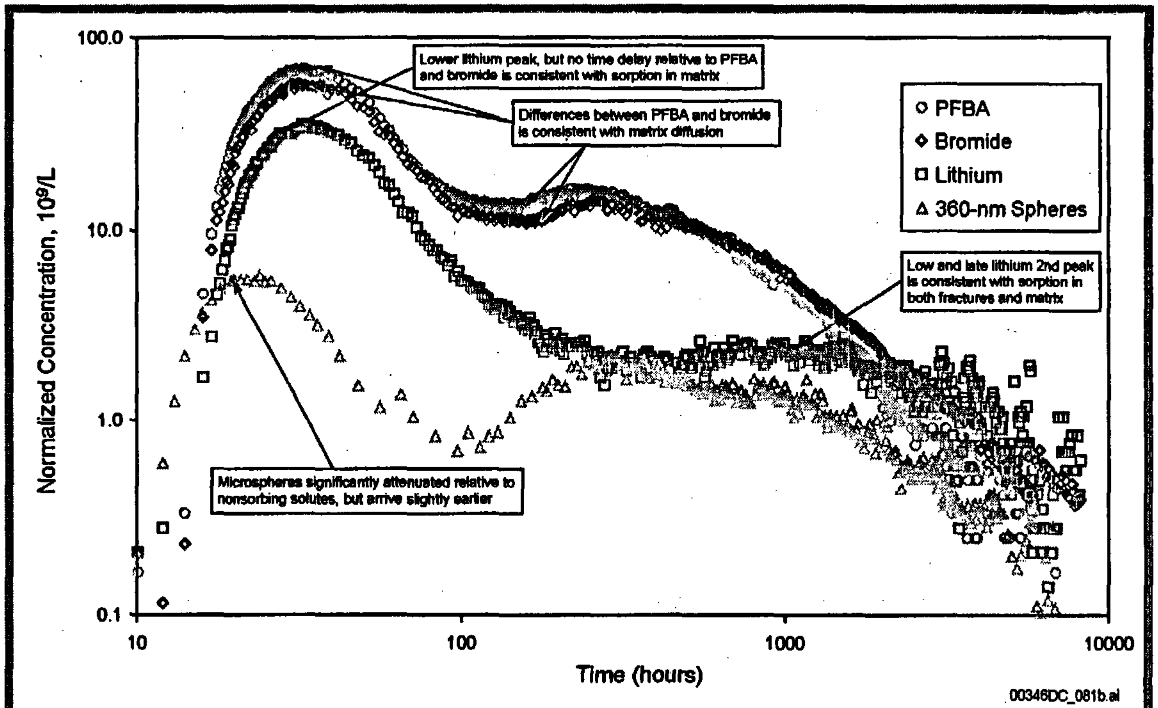
Summarize lab tests of sorption on alluvium

Summarize uncertainty distributions used in sorption parameter (K_d) for radionuclide transport model

NOTE: Additional details presented in Appendix K in response to KTI agreements RT 2.06, RT 2.07 and GEN 1.01 (#41 and #102)

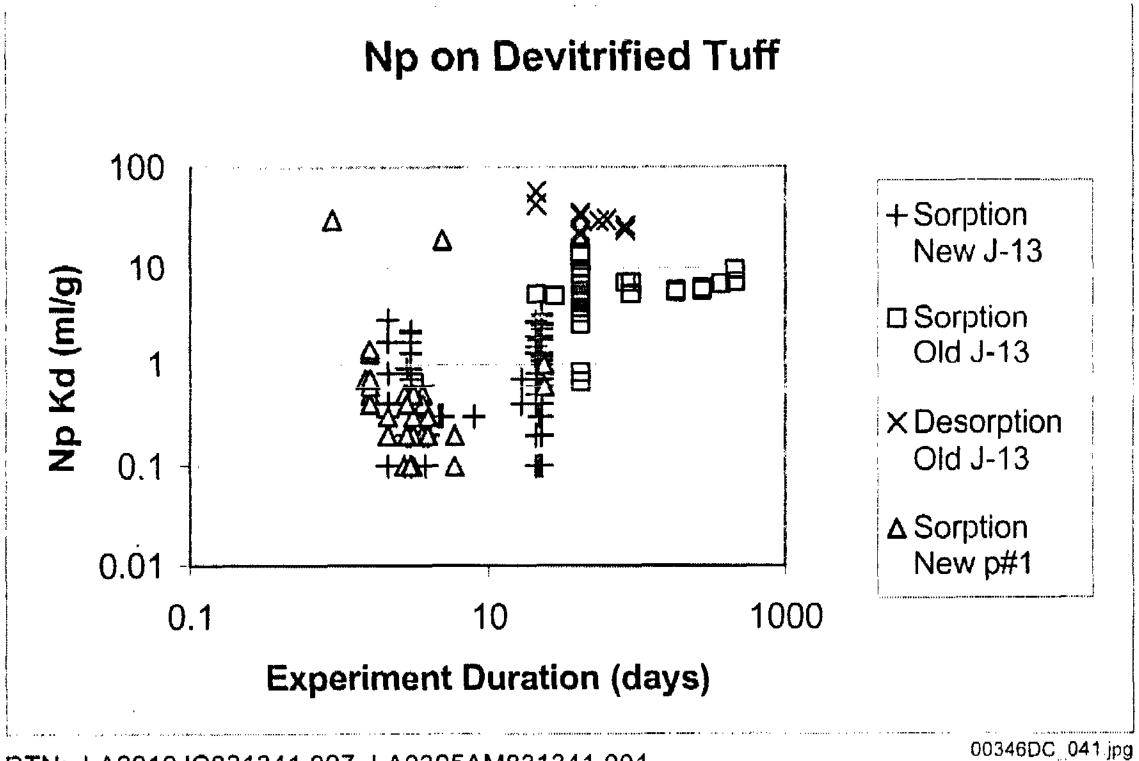
C-Wells Transport Test Data

- Tracer tests confirm dual continuum (fracture - matrix) transport model
- Matrix diffusion model confirmed (Bromide larger diameter than PFBA)
- Sorbing tracers (e.g., Lithium) behave analogously to lab sorption measurements
- Colloid mobility confirmed using microsphere analogs



PFBA - Pentafluorobenzoic Acid

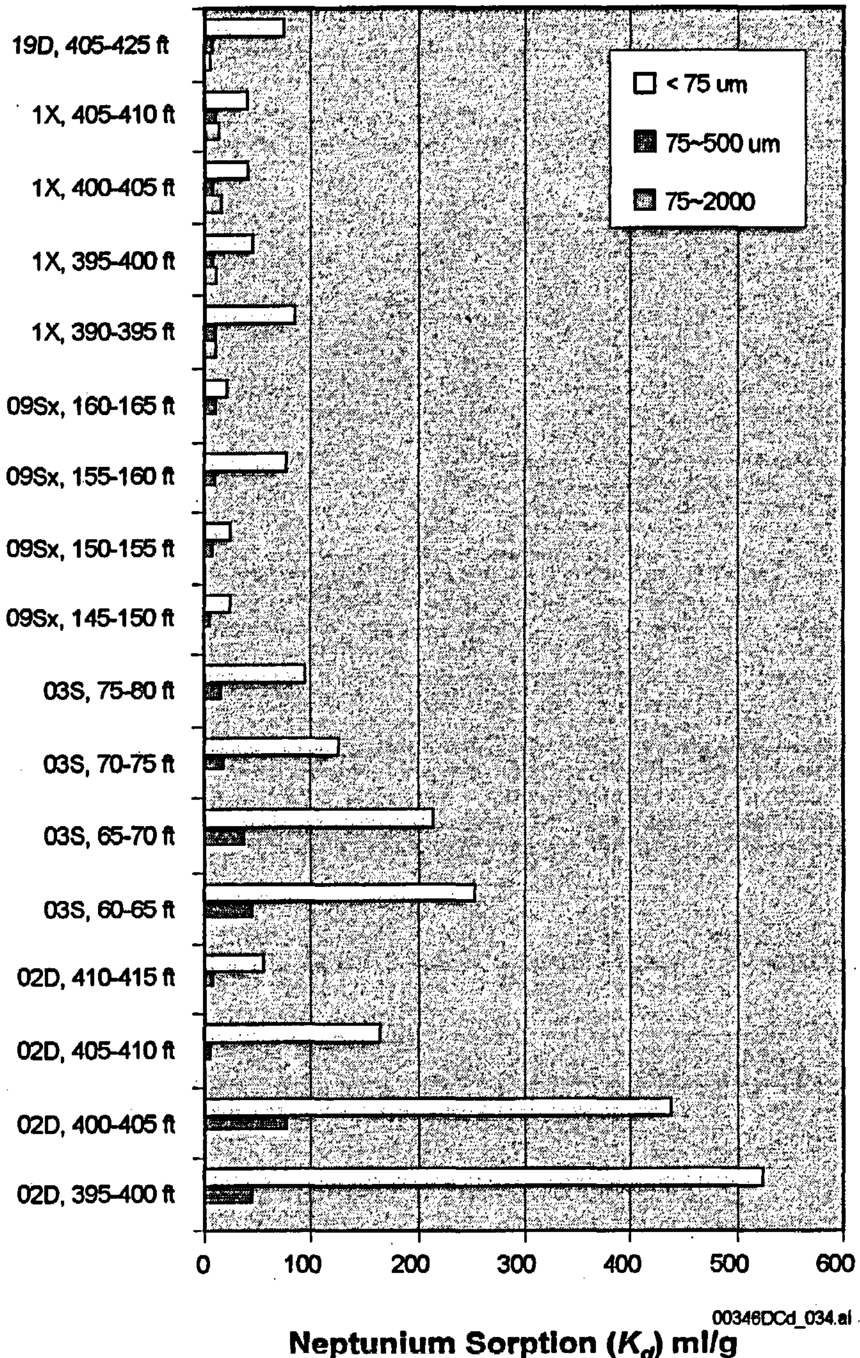
Sorption of Radionuclides on Tuff



DTN: LA0010JC831341.007, LA0305AM831341.001

NOTE: Experiments oversaturated with Np_2O_5 have been omitted.

- **Sorption (K_d) determined in lab tests**
- **Sorption is a function of radionuclide, chemistry and geologic media**
- **Data indicate "old" (pre-1990) and "new" (post-1990) tests using J-13 or p#1 water for both sorption and desorption experiments**



Sorption of Radionuclides on Alluvium

- **Np and U sorption evaluated using alluvium samples from Nye County boreholes**
- **Sorption is a function of grain size as smaller grains have higher percentage of clays**
- **75-2000 micron grain size tests only conducted using NC-EWDP-19D and -1X samples**

Saturated Zone Flow and Transport Technical Basis Document - Chapter 3

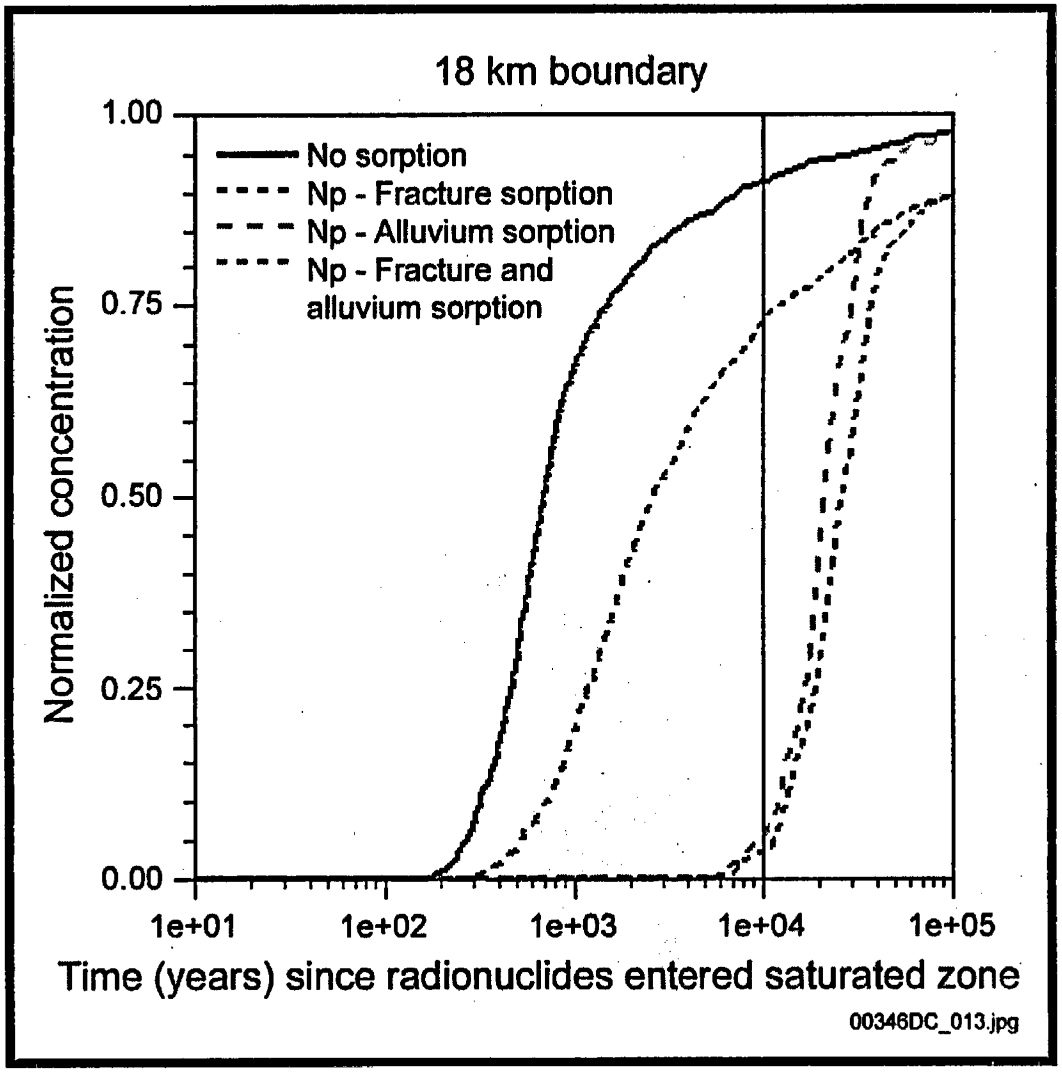
3.4 Site-Scale Radionuclide Transport Model

Summarize major parameter uncertainty

Present results of single realization of expected breakthrough times using means of input parameter values

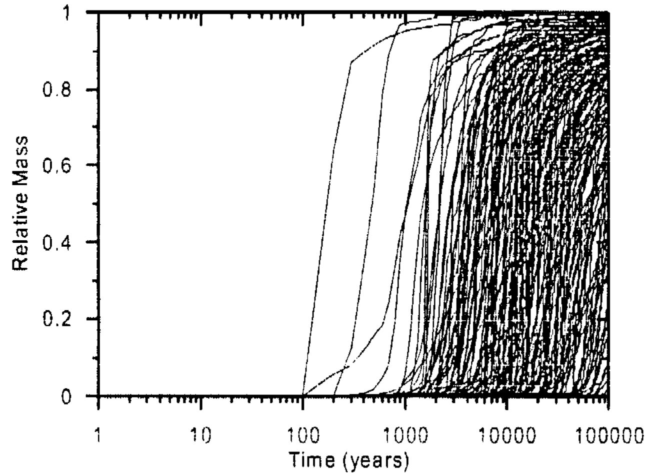
Present results of multiple realizations illustrating the effect of parameter uncertainty

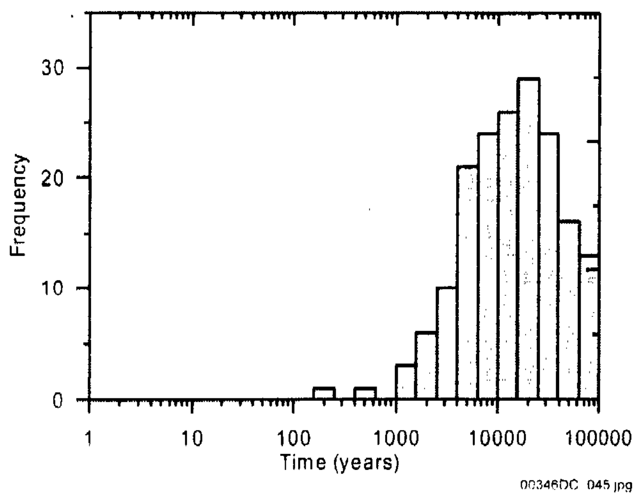
Predicted Radionuclide Mass Breakthrough



- **Plot indicative of nominal properties**
- **Mass flux for nonsorbing radionuclides indicates the bulk of the breakthrough occurs between several hundred and several thousand years**
  - **Consistent with C-14 interpretations**
- **Moderately sorbing species (Np-237) only ~ 5 percent breakthrough at 10,000 years**

Predicted Radionuclide Breakthrough - Neptunium





DTN: SN0306T0502103.008 [163947]

- **Neptunium is a moderately sorbing radionuclide (K_d between 1 and 10 ml/gm or Rd between about 10 and 100)**
- **Transport times generally between 1000 and > 100,000 years**
- **Mode of breakthrough distribution at about 20,000 years**

Summary and Conclusions

- Saturated Zone Flow and Transport Technical Basis Document typifies general structure and content of all Technical Basis Documents
- Each document presents the relevant processes and summarizes the major data sources used to describe those processes
- Each document presents the most significant parameters and their uncertainty
- Each document presents the major abstractions that are used in the postclosure performance assessment