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Bechtel SAIC Company, LLC

Technical Work Plan For:

IGNEOUS ACTIVITY ANALYSIS FOR DISRUPTIVE EVENTS

TWP-WIS-MD-000007
REV. 02

Work Package Numbers:
P4A1224DF1 / ADEM03, P4D1224DFU / ADET03, 8191225DUA

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REVISION HISTORY

Revision Number	Date of Revision	Purpose of the Revision
00	11/28/01	Initial issue
01	06/06/02	Revision to incorporate major Yucca Mountain Project-level changes referred to as 'Plan B.' Also incorporated model development and validation planning in greater detail than previous revision. (Changes are numerous, so vertical bars in the margins are not used to denote changes.)
02	11/01/02	Revision to incorporate changes in Total System Performance Assessment Department documentation requirements, changes in activities related to performance of modeling for dike propagation, and to address activities related to the igneous peer review panel. Also provides information for FY 2003 activities. Revision of this document is now required to comply with AP-2.27Q, *Planning for Science Activities*. Extensive changes were required, so this document is revised without the use of vertical change bars in the margin.

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TECHNICAL WORK PLAN FOR: IGNEOUS ACTIVITY ANALYSIS FOR DISRUPTIVE EVENTS

1. WORK SCOPE

This technical work plan (TWP) describes work to be performed in support of igneous activity analyses for both probability and consequence of igneous activity and the impact to the performance of the repository. In general, the work activities will expand the technical basis for License Application (LA), including additional support to satisfy the criteria of *Yucca Mountain Review Plan* (NRC 2002) and the related Key Technical Issue (KTI) agreements.

This TWP is being revised to address the requirements of the current applicable planning procedure, AP-2.27Q, *Planning for Science Activities*, and to more fully address FY 2003 activities. The TWP focuses on activities for FY 2003 and will provide detail only for those activities. However, some FY 2003 work is a continuation of and/or involves documentation of activities begun in FY 2002. Consequently, references to FY 2002 work packages are retained in this TWP. The work under this TWP impacts the Level 3 baseline.

The FY 2002 and FY 2003 work scope defined for the Igneous Activity work packages P4A1224DF1 (FY 2002 designation) and ADEM03 (FY 2003 designation) includes analysts in the Disruptive Events Department providing information to and interacting with an igneous peer review panel working for the Chief Science Officer (CSO). The work scope includes activities centered on the development, qualification, and verification of data and software; on model validation; and on the associated analyses. These activities are limited to data, software, models, and analyses that will be taken forward to LA. The work scope also includes preparation of analysis reports and model reports, which are collectively referred to as AMRs, that will provide data and model feeds to the various interfacing departments. To aid in transparency and traceability, a technical report will also be prepared that provides a roadmap summarizing the content of the AMRs. Fieldwork that supports data collection and analyses is covered under separate work packages: P4D1224DFU (FY 2002 designation) and ADET03 (FY 2003 designation). It is described at a summary level in this TWP. The U.S. Geological Survey (USGS) is providing support to field activities under work package 8191225DUA (FY 2003 designation).

The primary data and model feeds are to the Waste Package Department and to the Total System Performance Assessment (TSPA) Department. The Disruptive Events Department will also work with the Performance Assessment Project and the Performance Assessment Strategy and Scoping subproject that is overseeing construction of the Total System Performance Assessment for License Application (TSPA-LA) model.

In FY 2002, a peer review panel was convened by the CSO to review proposed work to analyze the consequences of igneous events (intrusive or eruptive) that may impact the performance of the repository. Recommendations from the peer review panel will provide guidance to the Disruptive Events Department regarding the appropriate scope of analyses for igneous consequence. The expected results of the panel's review are its recommendations defining an appropriate scope of work for analysis of the potential consequences of igneous activity impacting the repository. These recommendations will be assessed and may impact the scope of work being performed in FY 2003. Therefore, any future work described in this TWP in FY 2003 may be changed because of the outcome of the peer review and decisions made by the

Yucca Mountain Site Characterization Project (YMP) regarding implementation of peer review panel recommendations. Any such changes may require revision of the TWP per AP2.27Q requirements. The igneous peer review panel will also serve as a technical review panel as part of model validation activities.

Fieldwork in work packages P4D1224DFU (FY 2002 designation) and ADET03 (FY 2003 designation) supports the overall objectives of activities included by this TWP. The fieldwork is described at a summary level in the TWP. Fieldwork is described in more detail in the appropriate documents produced under AP-SIII.7Q, *Scientific Investigation Laboratory and Field Testing*, AP-5.2Q, *Testing Work Packages*, and the related SITP, *Test Plan for Ash Redistribution, Lava Morphology, and Igneous Processes Studies* (BSC 2002a). This TWP also describes work under work package 8191225DUA by the USGS in support of field investigations.

Production of documents, letter reports, or status reports from within the Natural Barrier departments that provide regulatory support/interaction are being addressed in a separate TWP: *Natural Barrier Systems KTI Preparation and Support* (TWP-NBS-MD-000003). It will cover work packages within various Natural Barrier System (NBS) departments, including work packages P421224UV2, P481224SX2, P491224BG, P4A1224DF9, AUZM12, ASZM06, ABIM04, ADEM03 and ADEM05. These work packages provide for technical staff to support License Application Project interactions to resolve/answer, status, and track issues/questions, commitments, and action items created as a result of U.S. Nuclear Regulatory Commission (NRC) staff review of U.S. Department of Energy (DOE) KTI agreement items and other pre-licensing submittals and during interactions (i.e., technical issue management).

1.1 Overall Technical and Performance Objectives

The high-level objective of the work described in the work packages covered by this TWP is to expand the technical basis for LA regarding the probability and consequence of igneous activity and the impact to the performance of the repository.

Table 1 briefly describes work scope and objective (s) for each of the work packages covered by this TWP.

1.2 Major Activities, Primary Tasks, and Products

This section lists the Activities and the associated Primary Tasks under the work packages covered by this TWP. Model development is more fully discussed in Section 2, along with specific model report discussions, to provide a consolidated discussion for Disruptive Events models. The term AMR in the following discussions refers collectively to both analysis reports (per AP-SIII.9Q, *Scientific Analysis*) and model reports (per AP-SIII.10Q, *Models*); the appropriate designation for each product will be determined through review and approval of the TWP for the activities.

Table 1. Disruptive Events: Major Activity Work Scopes and Objectives for FY 2002 and FY 2003

Report Title (DI Number), Work Package	Activity	Scope and Objective
Peer Review of Igneous Consequences Plan (No Analysis or Model Report) P4A1224DF1 and ADEM03	Support peer review of igneous consequences plan.	**Scope:** Provide information regarding past and ongoing work to support analysis of the probability and consequences of igneous activity. **Objective:** Support assessment by an external peer review panel of past and ongoing work to assist them in developing their basis for advising the Project regarding the appropriateness and adequacy of igneous activity analyses.
	Implement changes to igneous consequences analysis plans	**Scope:** Interact with Chief Science Officer, Natural Barrier System sub-project management, Performance Assessment Project management, and License Application Project to decide how, or whether, to adjust existing plans for igneous probability and consequence analysis and implement changes in YMP planning. **Objective:** Provide benefit to the YMP analytical approach for igneous consequence from external peer review of an analysis that is important to TSPA-LA.
Characterize Framework for Igneous Activity at Yucca Mountain, Nevada (ANL-MGR-GS-000001) P4A1224DF1 and ADEM03	Assess impact of new aeromagnetic survey results on probability	**Scope:** Analyze the results of aeromagnetic data that were collected after completion of *Probabilistic Volcanic Hazard Analysis for Yucca Mountain, Nevada* (CRWMS M&O 1996) and assess potential implications for the probability of intersection of the repository by a volcanic event. **Objective:** Determine what effect the number of buried anomalies detected by a USGS aeromagnetic survey could have on the probability output of *Probabilistic Volcanic Hazard Analysis for Yucca Mountain, Nevada* (CRWMS M&O 1996).
	Update probability calculation using the LA footprint	**Scope:** Recalculate the probability of intersection of the repository footprint by a volcanic event using the LA repository footprint. **Objective:** Provide TSPA-LA with a probability for a volcanic event that can be used for the Disruptive Events igneous scenarios.
	Revise analysis report in FY 2003	**Scope:** Document results of FY 2002 and FY 2003 work and update as needed. **Objective:** Provide TSPA-LA with a conceptual model of the igneous framework and parameters to support probability and consequence analysis of the Disruptive Events volcanic scenarios.

Table 1. Disruptive Events: Major Activity Work Scopes and Objectives for FY 2002 and FY 2003 (Continued).

Report Title (DI Number), Work Package	Activity	Scope and Objective
Science Support to Disruptive Events No Report 8191225DUA	USGS support to field activities	**Scope:** Support planning and execution of ash redistribution studies. **Objective:** Provide an improved scientific basis to support development of conceptual models and descriptive parameters for the processes by which erosion and redistribution of volcanic ash occurs after an eruption.
Characterize Eruptive Processes at Yucca Mountain, Nevada (ANL-MGR-GS-000002) P4A1224DF1 and ADEM03	Physical Volcanology in the Yucca Mountain Region	**Scope:** Evaluate results from Disruptive Events Field Investigations near Yucca Mountain in the area that includes the remnants of the Lathrop Wells Tephra sheet. **Objective:** Provide an improved scientific basis to support development of a conceptual model and descriptive parameters for the physical volcanological characteristics of the most likely type of eruption that could affect the repository.
	Ash/Sediment Redistribution in the Yucca Mountain Region	**Scope:** Evaluate results from Disruptive Events Field Investigations on ash/sediment redistribution near Yucca Mountain in Fortymile Wash and the vicinity of the reasonably maximally exposed individual. **Objective:** Provide an improved scientific basis to support development of conceptual models and descriptive parameters for the processes by which erosion and redistribution of volcanic ash occur after an eruption.
	Revise analysis report in FY 2003	**Scope:** Describe and update information about eruptive processes and parameters and ash/sediment redistribution processes and parameters that can be used to model process behavior to support analysis of the consequences of volcanic eruptions on the repository. **Objective:** Provide TSPA-LA with conceptual models and parameters to support analysis of the Disruptive Events volcanic eruption and igneous intrusion scenarios.

Table 1. Disruptive Events: Major Activity Work Scopes and Objectives for FY 2002 and FY 2003 (Continued).

Report Title (DI Number), Work Package	Activity	Scope and Objective
Disruptive Events Field Investigations No Report P4D1224DFU and ADET03	Physical Volcanology in the Yucca Mountain Region	**Scope:** Perform field investigations near Yucca Mountain in the area that includes the remnants of the Lathrop Wells Tephra sheet and possibly other analog sites. **Objective:** Provide an improved scientific basis to support development of a conceptual model and descriptive parameters for the physical volcanological characteristics of the most likely type of eruption that could affect the repository.
	Ash/Sediment Redistribution in the Yucca Mountain Region	**Scope:** Perform field studies near Yucca Mountain in Fortymile Wash and the vicinity of the reasonably maximally exposed individual. **Objective:** Provide an improved scientific basis to support development of conceptual models and descriptive parameters for the processes by which erosion and redistribution of volcanic ash occur after an eruption.
Roadmap to Igneous Activity Models, Analyses and Calculations (TDR-WIS-MD-000006) P4A1224DF1 and ADEM03	Develop annotated outline (FY 2002 and FY 2003)	**Scope:** Produce an annotated outline for a roadmap document identifying igneous activity documents, analyses, and parameter flow through these analyses, into TSPA-LA. **Objective:** Support development of a technical report in FY 2003, peer review panel briefing in FY 2002 and FY 2003, and TSPA integration and model abstraction for the two igneous activity scenarios.
	Develop new technical report in FY 2003	**Scope:** Produce a report documenting the underlying rationale, interrelationship and application of the analyses, models, and calculations for igneous activity probability and consequence analysis. **Objective:** Improve transparency and traceability of igneous activity probability and consequence analysis for TSPA-LA.

Table 1. Disruptive Events: Major Activity Work Scopes and Objectives for FY 2002 and FY 2003 (Continued).

Report Title (DI Number), Work Package	Activity	Scope and Objective
Dike Propagation Near Drifts (ANL-WIS-MD-000015) P4A1224DF1 and ADEM03	Dike Propagation– construct and test preliminary models and begin modeling for TSPA-LA	**Scope:** Analyze potential local effects on dike propagation caused by the altered zone created by the repository and topographic variability. **Objective:** Calculate the fracture propagation direction, the conditions and dike parameters at the point of intersection with the repository, the effects on subsequent dike growth of the magma loss into the repository; and the change in stresses on the repository due to the presence of the dike.
	Dike Propagation - validate model component	**Scope:** Validate model component per model validation plan (see Appendix A). **Objective:** Establish confidence that the model represents physical phenomena to the extent required.
	Magma and Gas Flow - construct and test preliminary model and begin modeling for TSPA-LA	**Scope:** Analyze the interaction of two-phase flow of magma with drifts, waste packages and debris in drifts. **Objective:** Determine the characteristics of the two-phase flow as magma enters and flows into drifts to define the environment to which engineered barrier system elements are exposed.
	Magma and Gas Flow - validate model component	**Scope:** Validate model component per model validation plan (see Appendix B). **Objective:** Establish confidence that the model represents physical phenomena to the extent required.
	Revise model report in FY 2003	**Scope:** Expand the mathematical and numerical modeling to support the Dike-Drift Interaction Model and update previous revision as needed. **Objective:** Provide TSPA-LA with an improved basis for igneous consequence modeling in the area of dike propagation and the interaction of magma with emplacement drifts.

Table 1. Disruptive Events: Major Activity Work Scopes and Objectives for FY 2002 and FY 2003 (Continued).

Report Title (DI Number), Work Package	Activity	Scope and Objective
Atmospheric Dispersal and Deposition of Tephra from a Potential Volcanic Eruption at Yucca Mountain, Nevada (MDL-MGR-GS-000002) P4A1224DF1 and ADEM03	Consolidate and update documentation of ASHPLUME model and code	**Scope:** Provide revised documentation of ASHPLUME model and code building on NRC and TSPA-SR documentation. **Objective:** Improve the documentation, transparency and traceability of the ASHPLUME code and model for TSPA-LA.
	Validate model and improve technical basis for selected parameters	**Scope:** Validate model per model validation plan (see Appendix C) and examine values and distributions of key ASHPLUME parameters. **Objective:** Provide the basis, supported by analog descriptions, for the applicability of using the ASHPLUME code and key parameter values to model volcanic ash dispersal for the volcanic eruption scenario. Provide an improved technical basis for selected parameters.
	Produce new model report in FY 2003	**Scope:** Document results of FY 2002 and FY 2003 tasks and provide stand-alone report to document the ash dispersal conceptualization, parameterization, and calculations. **Objective:** Provide an improved technical basis for using the ASHPLUME code to model volcanic ash dispersal for the volcanic eruption scenario for TSPA-LA. Provide ASHPLUME input parameters for implementing ASHPLUME in the GoldSim code.
Number of Waste Packages Hit by Igneous Intrusion (CAL-WIS-PA-000001) P4A1224DF1 and ADEM03	Review revised information from supporting documents in FY 2003	**Scope:** Review revisions to *Characterize Framework for Igneous Activity at Yucca Mountain, Nevada* (CRWMS M&O 2000a); *Characterize Eruptive Processes at Yucca Mountain, Nevada* (BSC 2001a); *Dike Propagation Near Drifts* (CRWMS M&O 2000b); and repository final design information. **Objective:** Identify any revisions to input parameters needed for the revision of *Number of Waste Packages Hit by Igneous Intrusion* (CRWMS M&O 2000c).
	Implement calculation using revised information in FY 2003	**Scope:** Revise calculation procedure and implement calculation using revised input information from supporting documents. **Objective:** Provide revised *Number of Waste Packages Hit by Igneous Intrusion* (CRWMS M&O 2000c). Provide input parameters to the TSPA–LA model.
	Provide analysis report in FY 2003	**Scope:** Document all revisions to the calculation including new and revised conceptual models and revised parameters and information from supporting documents, and any revisions to the calculation procedure. **Objective:** Update calculation using new and revised input information and new procedure.

1.2.1 Peer Review of Igneous Consequences Plan

No change in scope has occurred for this activity between this and the previous revision of the TWP. For the FY 2002 activity "Peer review of igneous consequences plan" and its supporting activities, the panel has produced an interim report. It is expected that interaction activities will continue during FY 2003. At the time of production of this revision of the TWP, the panel expects to produce a final recommendation report during the second quarter of FY 2003.

1.2.1.1 Activity—Support peer review of igneous consequences plan

Primary Tasks

- Interact with CSO representative for peer review.
- Provide roadmap annotated outline (See Section 1.2.8) and support interactions regarding previous work and ongoing work, with other explanatory material as needed, to support peer review panel understanding of the YMP approach to analysis of the probability and consequence of igneous activity that may impact the repository.
- Develop materials and make presentations.
- Facilitate integration with other groups outside of the Disruptive Events Department for support of this activity.
- Interact with the peer review panel as needed.

1.2.1.2 Activity—Implement changes to igneous consequences analysis plans

Primary Tasks

- Disruptive Events Department will assess peer review panel interim recommendations, determine implications for ongoing and planned future work, and have determinations reviewed by NBS subproject management who will send them to the CSO.
- Interact with the CSO representative, NBS subproject management, Performance Assessment group, and others, as appropriate, to determine whether Bechtel SAIC Company, LLC (BSC) will recommend to the DOE adjustments to the currently-planned approach for igneous consequences analysis based on peer review recommendations.
- Write revised plans as appropriate with scope, schedule, and budget.
- Implement revised plans, if needed.

1.2.2 Characterize Framework for Igneous Activity at Yucca Mountain, Nevada

Characterize Framework for Igneous Activity at Yucca Mountain, Nevada (CRWMS M&O 2000a) will be revised in FY 2003. The revision will document the results of the FY 2002 and FY 2003 activities (aeromagnetic anomaly analysis and modified repository footprint analysis) and provide any needed update to the Igneous Framework Conceptual Model. FY 2002 and FY 2003 activities associated with the report have the following primary tasks.

1.2.2.1 Activity—Assess impact of new aeromagnetic survey results on probability

Consideration of the number of volcanic events that have occurred during selected periods of time in the Yucca Mountain region was one of the key parameters used in the expert elicitation that is documented in *Probabilistic Volcanic Hazard Analysis for Yucca Mountain, Nevada* (CRWMS M&O 1996). This analysis used the number of volcanic events to calculate the probability of a basaltic dike intersecting the repository footprint. Volcanic features counted as volcanic events included individual volcanoes, alignments of volcanoes, and aeromagnetic anomalies in the region that are known (by drilling), or inferred to be, buried volcanic centers. In 1999, three years after *Probabilistic Volcanic Hazard Analysis for Yucca Mountain, Nevada* (CRWMS M&O 1996) was completed, a new aeromagnetic survey of the Yucca Mountain region was completed under the direction of the USGS. The aeromagnetic survey and maps were originally prepared on behalf of Nye, Clark and Inyo counties for mapping the hydrologic basins. The NRC suggested that they also be used to identify potential buried volcanic centers.

This activity assesses the impact of the updated information on the dike-repository intersection probability. Reanalysis and sensitivity calculations will be performed to assess the potential impact of additional volcanic events represented by the anomalies on the probability of intersection of the repository footprint by a basaltic dike.

Primary Tasks

- Conduct a scoping study to assess the methodology for incorporating new aeromagnetic data into the existing probabilistic volcanic hazard analysis framework. This will include an assessment of how volcanic events were counted and how additional events will be incorporated into the probabilistic volcanic hazard analysis parameters of event count, time period of interest, and "hidden events factor."

- Assess the probable age of each anomaly (with a probability of being a buried volcanic center) based on modeled depth of burial and geologic setting.

- Evaluate how the event counts would be assigned for the population of anomalies thought to represent buried volcanic centers. For example, an alignment of three buried volcanic centers could be considered to represent from one to three individual volcanic events, with a probability assigned for each alternative interpretation.

- Based on the results of the four preceding Primary Tasks, perform sensitivity calculations for the probability of intersection of the repository footprint. Several calculations will be performed to assess:

  - The sensitivity to the probability that anomalies represent buried volcanic centers

  - The sensitivity to the age assigned to anomalies

  - The sensitivity to using a "best estimate" of the distribution for the number of events represented by the anomalies (accounting for the uncertainty in whether the anomalies represent buried volcanic centers) versus a "worst-case" distribution for the number of events, where all anomalies are assumed to represent buried volcanic centers.

- Conduct assessment of whether the new information provided by the aeromagnetic data is adequately accounted for in the "hidden events factor" defined by *Probabilistic Volcanic Hazard Analysis for Yucca Mountain, Nevada* (CRWMS M&O 1996). The "hidden events factor" accounted for the possibility that not all volcanic events were known, due to burial or shallow intrusion without eruption. The PVHA experts generally assigned a factor of between 1.1 and 1.5, with one expert assigning a factor of 5.

- Provide support to document the analyses and to support development of a Letter Report for KTI agreement IA 1.02.

This activity began in April 2002. The final data will be submitted to the Technical Data Management System (TDMS) in the second quarter of FY 2003.

1.2.2.2 Activity—Update probability calculation using the LA footprint

In addition to the updated aeromagnetic data described above, the specifics of the footprint for the repository layout have been modified, which may also affect the probability of intersection. The start of this activity depends upon the availability of a new LA footprint.

Primary Tasks

- Use TSPA-LA footprint and results of *Probabilistic Volcanic Hazard Analysis for Yucca Mountain, Nevada* (CRWMS M&O 1996) to calculate the probability of intersection of the repository by a basaltic dike. Apply any updates to probabilistic volcanic hazard analysis results indicated by outcome of aeromagnetic data analysis activity.

- Use the results of the preceding Primary Task to calculate the number of eruptive centers (conduits) within the repository footprint and the length and azimuth of intersecting dikes within the repository footprint.

- Provide data to TSPA-LA.

The final results will be submitted to the TDMS in the second quarter of FY 2003. The submittal date is contingent on the receipt of repository layout information from Subsurface Design.

1.2.2.3 Activity—Revise Analysis Report in FY 2003

This activity involves issuing a revision of *Characterize Framework for Igneous Activity at Yucca Mountain, Nevada* (CRWMS M&O 2000a). The purpose of this activity is to document results of FY 2002 and FY 2003 work and provide updates as needed. The objective is to provide TSPA-LA with a conceptual model of the igneous framework and parameters to support probability and consequence analysis for the Disruptive Events volcanic scenarios.

The schedule cited in Section 1.4 for this and all AMRs covered by this TWP and funded at the time of development of this TWP, is to have the document finalized (through checking, review, and approval) before the required date for a feed of qualified data to TSPA-LA calculations for the Disruptive Events igneous activity scenarios. As needed, preliminary data will be sent to the TDMS to support development of the TSPA-LA model.

Primary Tasks

The activity of producing a revision, ICN, or a new document involves steps that can be represented by the following template. This template applies to production of all analysis, model, and technical reports described in this TWP and will not be repeated for each instance. The following template is intended to comply with the general format and outline requirements of AP-SIII.9Q, *Scientific Analysis*, AP-SIII.10Q, *Models*, and AP-3.11Q, *Technical Reports*. The template is also intended to satisfy the specific guidance and criteria provided in *Scientific Processes Guidelines Manual* (BSC 2002b) including those for parameter uncertainty and alternative conceptual models given in Section 5 and Appendices A and C of that document.

- Compile and format the document including text, graphics, and references.
- Document Sections 1, 2, and 4 and provide to the TSPA Department for review.
- Document Sections 3 and 5, including discussion on input parameter uncertainties and alternative conceptual models, and provide to the TSPA Department for review.
- Document Sections 6 and 7 including discussion on output parameter uncertainty and provide to the TSPA Department for review.
- If the document is a model report, perform the model validation activities per Section 5.4 of AP-SIII.10Q, including review by the CSO.
- Perform TDMS submittals.
- Submit document for Technical Checking including designated checker and the Quality Engineering Representative.
- Conduct review per AP-2.14Q, *Review of Technical Products and Data*.
- Finalize document and secure required approval signatures.

REV 01 will incorporate the following revisions:

- Sensitivity of the probability of intersection of the repository footprint by a basaltic dike to the possibility of additional buried volcanic centers identified through the USGS Amargosa Valley aeromagnetic survey
- Changes to the probability of intersection, azimuth and length of intersecting dikes within the repository footprint, and the number of eruptive centers within the repository footprint that result from repository design modifications that enlarge the repository footprint
- Updates to the Igneous Framework Conceptual Model based on new geophysical studies and probability studies published since REV 00 ICN 01 of the analysis report.

The final document will be prepared following AP-SIII.9Q, *Scientific Analyses* and will be provided in the third quarter of FY 2003.

1.2.3 Characterize Eruptive Processes at Yucca Mountain, Nevada

Characterize Eruptive Processes at Yucca Mountain, Nevada (BSC 2001a) will be revised in the third quarter of FY 2003. The revision will document the results of FY 2002 and FY 2003 activities, including the fieldwork on physical volcanology and ash/sediment redistribution addressed under the Disruptive Events Field Investigations conducted under work packages P4A1224DFU and ADET03. Analyses of the data will provide the basis for updating the eruptive processes conceptual model. FY 2002 and FY 2003 activities to be documented in the report have the following primary tasks.

1.2.3.1 Activity—Physical Volcanology in the Yucca Mountain Region

The primary purpose of this activity is to describe and update information about natural volcanic systems and the parameters that can be used to characterize their behavior to support analysis of the consequences of volcanic eruptions on the repository performance. The objective is to provide conceptual models and parameters to better support analysis of the Disruptive Events volcanic eruption scenario. This activity specifically allows for investigation of analog volcanic sites.

Primary Tasks

- Update conceptual model of eruptive processes in the Yucca Mountain Region.
- Evaluate eruption dynamics associated with the Lathrop Wells analog volcanoe through characterization of distribution and volumes of pyroclastic and effusive facies, xenolith content of pyroclastic deposits and lavas, vesicularity and morphology of pyroclasts, morphology of lavas.
- Characterize the Lathrop Wells Tephra sheet by evaluating the physical characteristics of the pyroclastic facies of the volcanic ash, such as deposit thickness, particle size distribution of deposit, and nature of ash deposit (air fall, pyroclastic surge).
- Update conduit diameter and dike width parameters and parameter uncertainties.
- Update description and parameterization for dike swarm geometry (number of dikes in a swarm and distance between dikes in a swarm).

Preliminary data will be submitted to the TDMS in the first quarter of FY 2003 and final data will be submitted in second quarter of FY 2003.

1.2.3.2 Activity – Ash/Sediment Redistribution in the Yucca Mountain Region

The primary purpose of this activity is to provide an improved scientific basis to support development of conceptual models and descriptive parameters for the processes by which erosion and redistribution of Tephra (and particularly, volcanic ash) occur downgradient toward the reasonably maximally exposed individual (RMEI). Direct observations and measurements of basaltic volcanic centers in the Yucca Mountain region, their products, and Tephra dispersal and erosional patterns and processes will provide the appropriate comparisons with a potential volcanic disruption of a repository at Yucca Mountain.

Primary Tasks

- Characterize ash redistribution through the Fortymile Wash drainage system by assessing bomb-pulse Cs-137 content and vertical distribution in the sediment profile. The objective of this task is to develop a geologic basis for the fate and transport of contaminated basaltic ash from hypothetical eruptions through a repository, after the eruptive products have been deposited in the form of a Tephra sheet.

- Characterize redistribution of the Lathrop Wells Tephra sheet by evaluating ash volume per unit volume of sediment and nature of ash deposit (air fall, fluvial reworking, and eolian reworking).

- Develop a conceptual model for ash/sediment redistribution in the Yucca Mountain Region. This conceptual model will support the TSPA-LA analysis of the accretion/erosion processes to improve/reassess parameter distribution for source term connected to ash/sediment redistribution.

- Compile, document and produce appropriate records of all data inputs, outputs and data reduction activities per YMP procedures and ensure all data are electronically transferred or input into appropriate YMP-controlled databases.

Preliminary and final data will be submitted to the TDMS in the second quarter of FY 2003.

1.2.3.3 Activity—Revise Analysis Report in FY 2003

This activity involves revising *Characterize Eruptive Processes at Yucca Mountain, Nevada* (BSC 2001a). The purpose of this activity is to evaluate and document the results of FY 2002 and FY 2003 fieldwork and FY 2003 processes analyses to provide appropriate updates. The objectives are to provide TSPA-LA with an updated eruptive processes conceptual model and related parameters and a Tephra redistribution conceptual model and parameters for ash/sediment redistribution processes. Meeting these objectives will support the consequence analysis for the Disruptive Events volcanic scenarios.

Primary Tasks

The activity of producing a revision, ICN, or a new document involves steps that can be represented by a template as previously described above in Section 1.2.2.3.

REV 01 will incorporate the following revisions:

- Update eruptive processes conceptual model and parameters for eruptive processes in the Yucca Mountain Region.

- Document a Tephra redistribution conceptual model and parameters for ash/sediment redistribution processes in the Yucca Mountain Region.

The final document will be prepared following AP-SIII.9Q, *Scientific Analyses* and will be provided in the third quarter of FY 2003.

1.2.4 Disruptive Events Field Investigations

The tasks for the field investigations, the results of which are to be documented in the revision of *Characterize Eruptive Processes at Yucca Mountain, Nevada* (BSC 2001a), are listed in *Test Plan for Ash Redistribution, Lava Morphology, and Igneous Processes Studies* (BSC 2002a). Support for these field activities will also be provided by the USGS.

1.2.4.1 Physical Volcanology in the Yucca Mountain Region

See description under Section 1.2.3.1.

1.2.4.2 Ash and Sediment Redistribution in the Yucca Mountain Region

See description under Section 1.2.3.2.

1.2.5 Dike Propagation Near Drifts

The FY 2002 and FY 2003 work on *Dike Propagation Near Drifts* (CRWMS M&O 2000b) represents a major revision of the existing document and will be based on expanding the numerical analytical support for the Dike-Drift Interaction Conceptual Model. The Dike-Drift Interaction Conceptual Model is supported by two model components: Dike Propagation and Magma and Gas Flow. One of the primary focuses of this work is to determine the viability of alternative dike propagation conceptual models.

The preceding revisions of this TWP indicated that the Magma and Gas Flow analysis would examine the interaction of magmatic products with "waste packages and debris" in drifts. The scope of this analysis under this model report has changed, and the Disruptive Events Department will not be analyzing effects on engineered barrier system (EBS) components. See Section 2, Interfaces with Organizations Using Output from this Work, for a description of output used by the Waste Package and Waste Form Departments for determining effects on EBS components.

Preliminary data will be submitted to the TDMS in the first quarter of FY 2003 and final data will be submitted to the TDMS in the second quarter of FY 2003.

1.2.5.1 Activity—Dike Propagation—Construct and test preliminary models and begin modeling for TSPA-LA

The Dike Propagation model component will be developed to calculate a) the fracture propagation direction, as affected by the repository (thermal and topographic effects); b) the pressure conditions and dike parameters at the point of intersection with the repository for use as initial conditions for the magma-drift analysis (Magma and Gas Flow model); c) the effect on subsequent dike growth of the magma loss into the repository; and d) the change in stresses on the repository due to the presence of the dike.

Primary Tasks

- Modify an existing hydraulic fracturing program (NPHF2D, version 1.0—after Detournay—and/or other applicable codes as needed), which is based on a displacement-discontinuity boundary element formulation. Modifications may include

modifying the code to replace a global leak-off parameter with grid-local leak-off parameters to address conditions at tunnel intersections, and inclusion of the proper fluid/gas constitutive behavior of the magma within the advancing fracture.

- Adapt existing mountain- and drift-scale thermo-mechanical analysis of the evolution of temperatures and stresses at the Yucca Mountain site for 10,000 years after waste disposal to develop stress trajectory data for dike propagation path analysis. Requires extracting existing stress profile information and putting the information into a form suitable for fracture code applications.

- Qualify the modified hydraulic fracture software per YMP procedure AP-SI.1Q, *Software Management.*

- Interact with project volcanologists to obtain the proper constitutive behavior of basaltic magma for inclusion in the analyses and provide interaction to couple the model with the model being generated to address Magma and Gas Flow.

1.2.5.2 Activity—Dike Propagation—Validate model component

Validate model component per AP-SIII.10Q, *Models*, and as described in the model validation plan included in Appendix A.

1.2.5.3 Activity—Magma and Gas Flow—Construct and test preliminary model and begin modeling for TSPA-LA

The Magma and Gas Flow output will be environmental conditions created by magmatic interaction with a model emplacement drift, both empty and with elements simulating either a single long, waste package the length of the drift, or a series of waste packages separated by air-filled gaps. The environmental conditions (temperature, pressure, and velocity of material) will be given as a function of the distance from the point of dike intersection. Phase changes in magmatic products will also be an output as a function of distance from the point of dike intersection.

Primary Tasks

- Modify an existing Los Alamos National Laboratory code (CFDLib or other applicable code(s)) as needed to determine conditions for pressure, temperature, and magma chemistry at various distances along the drift, and at various times following intrusion into the drift. Modifications will include equilibrium exsolution of volatiles (H_2O and CO_2) from silicate liquid, temperature- and composition-dependent magma viscosity, and the ability to output history of properties at specified points in the computational grid.

- Qualify the modified code per YMP procedures.

- Interact with project and other volcanologists to obtain the proper constitutive behavior of basaltic magma for inclusion in the analyses, and provide interaction to couple the model with the model being generated to address Dike Propagation.

1.2.5.4 Magma and Gas Flow—Validate model component

Validate model component per AP-SIII.10Q, *Models* and as detailed in the model validation plan included in Appendix B..

1.2.5.5 Activity—Revise Model Report in FY 2003

This activity encompasses revising the existing analysis reported in *Dike Propagation Near Drifts* (CRWMS M&O 2000b). The purpose is to document the expanded numerical modeling performed in FY 2002 and FY 2003 to support the Dike-Drift Interaction Model. The objective is to provide TSPA-LA with an improved basis for igneous consequence modeling in the area of dike propagation and the interaction of magma with emplacement drifts.

The revised report will be issued as an model report that addresses the modeling performed to address Dike Propagation and the Magma and Gas Flow analysis. This revision will be co-authored by the analysts evaluating the Dike Propagation and the Magma and Gas Glow model components and will be performed as part of FY 2003 activities.

Tasks are the same as for production of the AMRs as described previously in Section 1.2.2.3. The final document will be prepared following AP-SIII.10Q, *Models* and will be provided in the third quarter of FY 2003.

1.2.6 Atmospheric Dispersal and Deposition of Tephra from a Potential Volcanic Eruption at Yucca Mountain, Nevada

Atmospheric Dispersal and Deposition of Tephra from a Potential Volcanic Eruption at Yucca Mountain, Nevada (MDL-MGR-GS-000002) is a new report. Primary tasks are as follows.

1.2.6.1 Activity—Consolidate and update documentation of ASHPLUME model and code

Primary Tasks

- Provide documentation of the atmospheric dispersal conceptual model and the mathematical model employed by ASHPLUME to implement the conceptual model.
- Perform a literature search to determine whether any other ash/waste dispersal code (other than ASHPLUME) is applicable to modeling a strombolian igneous event of the eruptive type most probable at Yucca Mountain. Compare other potential ash/waste dispersal models found in the literature to the ASHPLUME mathematical model and justify use of the ASHPLUME mathematical model over other potential models.
- Develop an improved technical basis for selected ASHPLUME model parameter values and distributions.

1.2.6.2 Activity—Validate model and improve technical basis for selected parameters

Primary Tasks

- Validate ASHPLUME mathematical model per model validation plan.
- Use field data from Disruptive Events Field Investigations for Tephra thickness and grain size from the Lathrop Wells volcano as an analog to calibrate an ASHPLUME model specific to the Yucca Mountain region. Support analog development for the eruptive processes model report in FY 2003.
- Determine whether the currently used values or distribution of values for selected key parameters are appropriate as inputs to ASHPLUME and develop updated parameter values/distributions as appropriate. Parameters to be investigated include:
  - Incorporation ratio, which determines the ratio of waste particle size to total particle size
  - Particle shape factor, which affects ash/waste settling velocities and therefore, ash/waste distribution in deposits from the ash cloud
  - Ash dispersion coefficient (β)
  - Wind speed and direction as a function of height. Determine whether the appropriate wind speed is being used for various heights of the volcanic eruption column
  - Wind direction data—evaluate different approaches for incorporating
  - ASHPLUME eruption velocity.
- Conduct sensitivity analyses to determine the relative importance of specific parameters to the calculation of ash/waste distribution.
- Provide initial ash dispersal calculations using the ASHPLUME code to predict expected ash/waste distribution in the Yucca Mountain region due to an igneous eruptive event to be used in the calculation of eolian and fluvial remobilization and transport of ash/waste particles. Provide initial ash/waste particle-size distributions for determining changes in particle-size distributions during fluvial/eolian transport.
- Provide sensitivity calculations using the ASHPLUME code to assess the impact to erupted ash/waste particle size distributions due to the conceptualization of magma-waste form interaction and the conceptualization of ash/waste particle incorporation ratio.

The model validation plan is attached in Appendix C to this TWP. Results are scheduled to be submitted to the TDMS in the first quarter of FY 2003.

1.2.6.3 Activity—Produce new Model Report in FY 2003

This activity encompasses preparation and submission of *Atmospheric Dispersal and Deposition of Tephra from a Potential Volcanic Eruption at Yucca Mountain, Nevada* (MDL-MGR-GS-000002). The purpose of this model report is to document results of FY 2002 and FY 2003 tasks and provide a stand-alone report to document the ash dispersal conceptualization, parameterization, and calculations. The objectives are to provide an improved technical basis for using the ASHPLUME code to model volcanic ash dispersal for the volcanic eruption scenario for TSPA-LA, and to provide ASHPLUME input parameters for implementing ASHPLUME in the GoldSim code.

Tasks are the same as for production of the AMRs as described previously in Section 1.2.2.3. The final document will be prepared following AP-SIII.10Q, *Models*, and will be provided in the first quarter of FY 2003.

1.2.7 Number of Waste Packages Hit by Igneous Intrusion

Number of Waste Packages Hit by Igneous Intrusion (CRWMS M&O 2000c) had no activities associated with it for FY 2002. At a high level, the following are tasks expected to be part of the FY 2003 revision of the analysis report. Specific tasks for FY 2003 may depend on the outcome of the peer review panel activity.

1.2.7.1 Activity—Review revised information from supporting documents in FY 2003

Review revisions to *Characterize Framework for Igneous Activity at Yucca Mountain, Nevada* (CRWMS M&O 2000a); *Characterize Eruptive Processes at Yucca Mountain, Nevada* (BSC 2001a); *Dike Propagation Near Drifts* (CRWMS M&O 2000b); and repository final design information.

1.2.7.2 Activity—Implement calculation using revised information in FY 2003

Primary Tasks

- Document the rationale for application of the conceptual model for the location(s) of conduit formation within the repository footprint to calculate the number of waste packages directly in a conduit for the TSPA-LA footprint.
- Document the rationale for application of the conceptual model for the number of waste packages directly contacted by a dike intersection and for waste packages in varying magmatic-related environmental zones.
- Calculate the number of waste packages in various magmatic-related environmental zones for TSPA-LA.

Preliminary and final results are scheduled for submission to the TDMS in the third quarter of FY 2003.

1.2.7.3 Provide Analysis Report in FY 2003

This activity involves an update and revision to *Number of Waste Packages Hit by Igneous Intrusion* (CRWMS M&O 2000c). The purpose of this analysis report is to document all revisions to the calculation including new/revised conceptual models and revised parameters/ information from supporting documents, and any revisions to the calculation procedure. The objective is to update the calculation using new/revised input information and the new procedure.

Tasks are the same as for production of AMRs as described previously in Section 1.2.2.3. The final document will be prepared following AP-SIII.9Q, *Scientific Analyses* and will be provided in the third quarter of FY 2003.

1.2.8 Roadmap to Igneous Activity Models, Analyses, and Calculations

Roadmap to Igneous Activity Models, Analyses and Calculations (TDR-WIS-MD-000006) is a new technical report and had an FY 2002 activity to produce an annotated outline to support the FY 2002 peer review of the igneous consequences plan. The annotated document will be maintained during FY 2003 until the final document is produced. Development and issuance of this document is planned for late FY 2003.

1.2.8.1 Activity—Develop Annotated Outline

In FY 2002, an annotated outline of Igneous Activity models, analyses and calculations was developed and maintained. In FY 2003, this annotated outline will be maintained to a) identify all Disruptive Events models and analyses; and b) identify the flow of conceptual models, numerical and mathematical models, model abstractions, and parameters within the Disruptive Events Department, to and from other YMP Departments, and into the TSPA-LA.

1.2.8.2 Complete Technical Report in FY 2003

This activity involves preparation and submission of *Roadmap to Igneous Activity Models, Analyses, and Calculations* (TDR-WIS-MD-000006). The purpose of this new technical report is to document the underlying rationale, interrelationship and application of the analyses, models, and calculations for igneous activity probability and consequence. The objectives of the annotated outline and the report are to support transparency and traceability of the analyses, models, and calculations for igneous activity. At a minimum, the report will provide traceability of the integration of model abstractions and parameters into the TSPA-LA.

Tasks are the same as for production of AMRs as described previously in Section 1.2.2.3. The final document will be prepared following AP-3.11Q, *Technical Reports,* and will be provided in the fourth quarter of FY 2003.

1.3 Organizations Performing Work and Responsible for Work Products

The Performance Assessment Project is responsible for the overall work effort. Within the Performance Assessment Project, the work described in this TWP primarily encompasses activities by the Disruptive Events Department within the NBS subproject. The organization responsible for the work effort described in this TWP is the Disruptive Events Department. Technical services subcontractors will be required to support the work.

The scope includes compliance actions to achieve approval of the TWP, including the CSO organization's review. In FY 2002, a peer review panel was convened by the CSO to review proposed work to analyze the consequences of igneous events (intrusive or eruptive) that may impact the repository.

Work under work packages P4A1224DF1 and ADEM03 is managed and performed by the Disruptive Events Department. The NBS subproject through the Natural Barrier–Testing Department manages work packages P4D1224DFU and ADET03, *Disruptive Events Field Investigations*, with staff from the Disruptive Events Department performing most of the work. Additional support to the fieldwork will be provided by the USGS. The USGS assisted in planning and execution of field activities in FY 2002 and similar USGS support will continue in FY 2003. Work package 8191225DUA, *Science Support to Disruptive Events*, is managed by the USGS and covers USGS support to the activity Disruptive Events Field Investigations.

1.4 Schedule for Activities

A primary driver for the schedule for all AMRs covered by this TWP and funded at the time of development of this TWP is to have the documents finalized (through checking, review, and approval) before the required date for a feed of qualified data to TSPA-LA calculations for the Disruptive Events igneous activity scenarios. Specific dates are included in the YMP P3 schedule. For details of the FY 2003 schedule see the BSC Multi-Year Planning System data available online at the BSC Intranet site. Table 2 provides a list of the anticipated deliverables and the planned timing for submission.

2. SCIENTIFIC APPROACH OR TECHNICAL METHODS

As previously stated, the high-level objective of the work described in the work packages covered by this TWP is to expand the technical basis for LA regarding the probability and consequence of igneous activity and the impact to the performance of the repository. This will primarily be accomplished through the development and qualification of software, model validation, and a series of igneous-related analyses, which will be documented in the associated AMRs.

The following activities and the associated update of the AMRs described in this TWP will include material on topics specified by the Performance Assessment Strategy and Scoping subproject and other user groups. Examples of this type of material include the contextual support for the AMRs that that is described in *Scientific Processes Guidelines Manual* (BSC 2002b) and that was formerly provided by *Disruptive Events Process Model Report* (CRWMS M&O 2000d). That process model report will not be revised in FY 2003.

Table 2. Disruptive Events Deliverables Schedule

Activity and/or Documents for TSPA-LA	Delivery Schedule
Peer Review of Igneous Consequences Plan (No AMR)	No deliverables scheduled
Characterize Framework for Igneous Activity at Yucca Mountain, Nevada (ANL-MGR-GS-000001)	Final data will be submitted to the Technical Data Management System in the second quarter of FY 2003 The final document will be provided in the third quarter of FY 2003.
Characterize Eruptive Processes at Yucca Mountain, Nevada (ANL-MGR-GS-000002)	For physical volcanology, preliminary data will be submitted to the Technical Data Management System in the first quarter of FY 2003 and final data will be submitted in second quarter of FY 2003. For ash/sediment redistribution, preliminary and final data will be submitted to the technical management data system in the second quarter of FY 2003. The final document will be provided in the third quarter of FY 2003.
Disruptive Events Field Investigation (No Report)	No deliverables scheduled
Dike Propagation Near Drifts (ANL-WIS-MD-000015)	Preliminary data will be submitted to the Technical Management Data System in the first quarter of FY 2003 and final data will be submitted to the Technical Data Management System in the second quarter of FY 2003. The final document will be provided in the third quarter of FY 2003.
Atmospheric Dispersal and Deposition of Tephra from a Potential Volcanic Eruption at Yucca Mountain, Nevada (MDL-MGR-GS-000002)	Results will be submitted to the Technical Data Management System in the first quarter of FY 2003. The final document will be provided in the first quarter of FY 2003.
Number of Waste Packages Hit by Igneous Intrusion (CAL-WIS-PA-000001)	Preliminary and final results will be submitted to the Technical Management Data System in the third quarter of FY 2003. The final document will be provided in the third quarter of FY 2003.
Roadmap to Igneous Activity, Models, Analyses, and Calculations (TDR-WIS-MD-000006)	The final document will be provided in the fourth quarter of FY 2003.

The Disruptive Events AMRs and related models described in this TWP are as follows:

- *Characterize Framework for Igneous Activity at Yucca Mountain, Nevada* (CRWMS M&O 2000a)

  Igneous Framework Conceptual Model

- *Characterize Eruptive Processes at Yucca Mountain, Nevada* (BSC 2001a)

  Eruptive Processes Conceptual Model
  Tephra Redistribution Conceptual Model

- *Dike Propagation Near Drifts* (CRWMS M&O 2000b)

  Dike-Drift Interaction Conceptual Model
  Model Component: Dike Propagation
  Model Component: Magma and Gas Flow
  Post-Event Repository Conceptual Model

- *Atmospheric Dispersal and Deposition of Tephra from a Potential Volcanic Eruption at Yucca Mountain, Nevada* (MDL-MGR-GS-000002)

  ASHPLUME Conceptual Model
  ASHPLUME Mathematical Model

- *Number of Waste Packages Hit by Igneous Intrusion* (CRWMS M&O 2000c)

  Waste Packages Hit Conceptual Model

Models and modeling activities for the igneous scenarios will be discussed in the following sections. The tasks for each model (described in Section 1.2) will develop the various model components. The tasks associated with justification of model use, model validation plans, the level of confidence required, the validation methods, and the model validation criteria are contained in the model validation plans for the individual numerical models that are included in Appendices A through C.

The generic plan for treatment of alternative conceptual models, model abstraction and uncertainties is outlined in Appendices A and C of *Scientific Processes Guidelines Manual* (BSC 2002b). Documentation will follow these YMP guidelines at the time of revision of the AMRs. A very brief discussion of these topics for each model is also included in the following subsections. Investigators and subject matter experts for the activities described below will integrate their activities and consideration of alternate models, abstractions, and parameters with the Abstraction Team Lead and the Parameter Team Lead, as described in Appendix A of *Scientific Processes Guidelines Manual* (BSC 2002b), which also includes guidance regarding the relation of modeling and analysis activities to the treatment of included features, events, and processes (FEPs).

Disruptive Events FEPs

Work to evaluate both seismic and igneous-related FEPs is being managed within work packages P4A1224DFA (FY 2002 designation) and ADEM06 (FY 2003 designation) and, consequently, is not described as a separate activity in this TWP. That work, along with technical and background information pertaining to screening of seismic-related FEPs, will be described in *Development of Seismic Design Inputs, Preparation of a Seismic Topical Report, and Evaluation of Disruptive Events Features, Events, and Processes* (BSC 2002c – in preparation). Detailed technical information is provided in this TWP only for the igneous-related FEPs. This documentation structure keeps the management of the activity to evaluate disruptive events FEPs within one work package, but provides background, technical information, and lists of related FEPs within the related subject matter TWP and the documenting AMRs.

Evaluations of disruptive events FEPs was previously documented for the Total System Performance Assessment for Site Recommendation (TSPA-SR) and will continue to take place during FY 2003. Events with less than 1 chance in 10,000 of occurring in 10,000 years (or approximately equivalent to an annualized probability of less than 10^{-8}) or which have a low consequence to dose will be excluded from the TSPA-LA. The remaining FEPs will be included in the TSPA-LA. Evaluation of FEPs will be carried out on the basis of available data, analyses, and models. Activities will include a review of updated project analysis reports and model reports prepared by the Disruptive Events Department and other project departments, as appropriate. Other external literature may be reviewed if pertinent to the FEPs discussion. Activities will also include integration with subject matter experts from within the Disruptive Events Department, the TSPA Department, and other departments based on the FEPs descriptions, related-KTI agreements, and TSPA-LA modeling issues. Based on these activities, a FEPs screening decision will be reached by consensus. These decisions will be provided in a preliminary form to the Performance Assessment Strategy and Scoping subproject and to the TSPA Department for incorporation into the TSPA-LA model, and will be fully documented in a revision of the FEPs analysis report.

Preliminary screening decisions will be provided to the TSPA Department in the first quarter of FY 2003 and will be documented in a revision of *Features, Events, and Processes: Disruptive Events* (CRWMS M&O 2000e). The revision of this analysis report is scheduled for completion during the third quarter of FY 2003. The citable source for the technical basis for included igneous-related FEPs will be the revisions of the AMRs described in this TWP. The FEPs activities, including preparation of the preliminary decisions and documentation of these decisions, are discussed more fully in Section 2.3 of *Development of Seismic Design Inputs, Preparation of a Seismic Topical Report, and Evaluation of Disruptive Events Features, Events, and Processes* (BSC 2002c – in preparation).

Table 3 provides a cross-reference between the listed activities and the existing primary FEPs from the TSPA-SR FEPs list that are related to the activities discussed within this TWP.

A preliminary review of the existing documentation has indicated that changes to the igneous-related FEPs will be needed to bring existing FEPs documentation into agreement with the format and grouping provisions of Section 3 of *The Enhanced Plan for Features, Events, and Processes (FEPs) at Yucca Mountain* (BSC 2002d) and to address existing KTI agreements. The status of igneous-related FEPs and preliminary recommended changes to the FEPs organization and screening decisions are summarized in Table 4. Recommended changes are subject to review of the FEPs database team.

It is also anticipated that that stronger technical arguments should be developed to comply with existing KTI agreements for some igneous-related FEPs. Supporting documentation will be cited in the FEPs analysis report, and will be cited primarily from subject-specific analysis and model reports to allow traceability of the basis for the screening decision. The Disruptive Events AMRs and related models that will be used to support these FEPs include but are not limited to those previously listed above.

Table 3. Major Activities and Document for TSPA-LA, and Related FEPs from TSPA-SR: Work Packages P4A1224DF1 and ADEM03, and Work Packages P4D1224DFU and ADET03

Activity and/or Documents for TSPA-LA	TSPA-SR Related – FEP Title
Peer Review of Igneous Consequences Plan (No AMR)	Does not directly address FEPs
Characterize Framework for Igneous Activity at Yucca Mountain, Nevada (ANL-MGR-GS-000001)	1.2.04.01.00 Igneous Activity 1.2.04.02.00 Igneous Activity Causes Changes to Rock Properties 1.2.04.03.00 Igneous Intrusion into Repository 1.2.10.02.00 Hydrogeologic Response to Igneous Activity
Characterize Eruptive Processes at Yucca Mountain, Nevada (ANL-MGR-GS-000002)	1.2.04.01.00 Igneous Activity 1.2.04.05.00 Magmatic Transport of Waste 1.2.04.06.00 Basaltic Cinder Cone Erupts through the Repository 1.2.04.07.00 Ashfall
Disruptive Events Field Investigation (No Report)	1.2.04.01.00 Igneous Activity 1.2.04.06.00 Basaltic Cinder Cone Erupts through the Repository 1.2.04.07.00 Ashfall
Dike Propagation Near Drifts (ANL-WIS-MD-000015)	1.2.04.01.00 Igneous Activity 1.2.04.02.00 Igneous activity causes changes to rock properties 1.2.04.03.00 Igneous Intrusion into Repository 1.2.04.04.00 Magma Interacts with Waste 1.2.04.05.00 Magmatic Transport of Waste 1.2.10.02.00 Hydrogeologic Response to Igneous Activity
Atmospheric Dispersal and Deposition of Tephra from a Potential Volcanic Eruption at Yucca Mountain, Nevada (MDL-MGR-GS-000002)	1.2.04.01.00 Igneous Activity 1.2.04.06.00 Basaltic Cinder Cone Erupts through the Repository 1.2.04.07.00 Ashfall
Number of Waste Packages Hit by Igneous Intrusion (CAL-WIS-PA-000001)	1.2.04.01.00 Igneous Activity 1.2.04.04.00 Magma Interacts with Waste 1.2.04.05.00 Magmatic Transport of Waste 1.2.04.06.00 Basaltic Cinder Cone Erupts through the Repository
Roadmap to Igneous Activity, Models, Analyses, and Calculations (TDR-WIS-MD-000006)	Does not directly address igneous FEPs, but aids in addressing FEPs traceability and transparency

Table 4. Summary of TSPA-LA Status for Igneous-Related FEPs for TSPA-LA.

FEP	TSPA-SR Decision	Preliminary TSPA-LA Status
1.2.04.01.00 Igneous Activity	Include/ Exclude	Delete this FEP due to its broad categorization. Move existing topics into other igneous-related FEPs
1.2.04.02.00 Igneous Activity Causes Changes to Rock Properties	Exclude	Exclude—modify FEP description to address rock stress and deformation of rock
1.2.04.03.00 Igneous Intrusion Into Repository	Include	Include—name to "Igneous Intrusion Intersects Repository" and modify FEP description to address dike-drift interaction conceptual model
1.2.04.04.00 Magma Interacts with Waste	Include	Include—change name to " Volcanic Products Interact with EBS Components" and modify FEP description to include interaction with drift, invert, drip shield, and waste packages
1.2.04.05.00 Magmatic Transport of Waste	Exclude/ Include	Exclude—change name to "Scoria Cone Development and Magmatic Transport of Waste" and revise description to focus on entrainment of waste in surface transport mechanisms
1.2.04.06.00 Basaltic Cinder Cone Erupts Through Repository	Include	Include—change name to "Conduit Intersects Drift" and revise FEP description to focus on conduit development and waste entrainment, rather than cinder cone development
1.2.04.07.00 Ashplume	Include	Include—no changes recommended
1.2.10.02.00 Hydrologic Response to Igneous Activity	Exclude	Exclude—no change recommended
(New) Ash Redistribution and Redeposition	Include	Include—new FEP to address post event reworking of ash/sediment in and toward the vicinity of the RMEI.

Flow and Use of Information

Figure 1 shows, at a high level, the flow of information from the disruptive events models into the two disruptive event igneous scenarios modeled in TSPA-LA. Figure 1 also illustrates the pathway of information flow within the Disruptive Events Department and also the flow of information from the Disruptive Event Department to the associated users/customers of the products developed under this TWP. These users/customers include the TSPA Department, the Biosphere Department, the Waste Form Department, and the Waste Package Department. The TSPA Department is responsible for integration of the results and models, produced by the respective departments, into the TSPA-LA model to determine the volcanic eruption dose and the groundwater igneous intrusion dose.

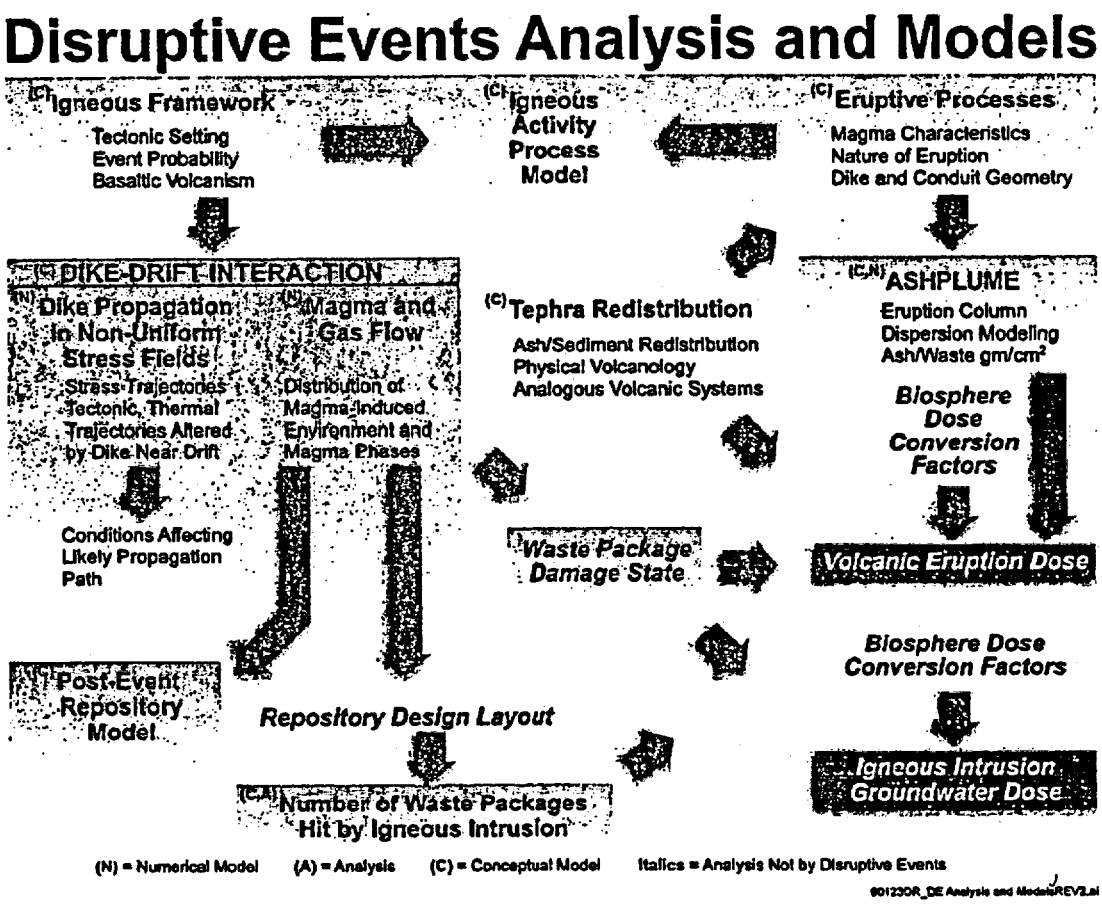

Figure 1. Disruptive Events Analysis and Models

Interfaces with Organizations Providing Input to this Work

Subsurface Design

For use in analyses to be associated with the revisions of *Dike Propagation Near Drifts* (CRWMS M&O 2000b), *Number of Waste Packages Hit by Igneous Intrusion* (CRWMS M&O 2000c), and *Characterize Framework for Igneous Activity at Yucca Mountain, Nevada* (CRWMS M&O 2000a), the Disruptive Events Department will receive design input from the Subsurface group that includes the coordinates of the repository footprint (in UTM coordinates), overall repository layout, the design grade in drifts, as well as identification, sizes, and shapes of ventilation shafts and drifts that will be open after closure. This will be provided in the form of design drawings or documents, particularly *Underground Layout Configuration* (BSC 2002e) and taken from the IED. The Disruptive Events Department will also utilize the results of previous in situ stress analyses, such as those performed in association with updates to *Drift Degradation Analysis* (BSC 2001b). This information will be extracted from the TDMS or other YMP-controlled sources.

Waste Package and Waste Package Design

There is no planned or required feed from the Waste Package Department to the Disruptive Department regarding igneous-induced waste package damage. The Waste Package Department and the Disruptive Events Department activities related to this subject area are on parallel tracks that feed to the TSPA Department. Magmatic-related environmental zones within the drift during and following an igneous event and the associated number of packages involved will be discussed in *Number of Waste Packages Hit by Igneous* (CRWMS M&O 2000c). In order to correlate this with the zonation of damage states associated with various environmental conditions, the Disruptive Events Department would require input information from the Waste Package Department in the form of an igneous-induced damage state analysis. The defined damaged zones would need to be related to the environments created by a magmatic intrusion. Such a damage state analysis is being trended. If the work is approved and performed, the planned revision of *Number of Waste Packages Hit by Igneous Intrusion* (CRWMS M&O 2000c) may reference the resulting document to support a brief discussion relating magmatic environmental zones to the damage states presented by the Waste Package Department.

Interfaces with Organizations Using Output from this Work

All outputs from the Disruptive Events modeling to be used by other organizations will be submitted to the TDMS or other YMP procedurally directed databases for use by other organizations. The technical basis for the outputs will be documented in the AMRs described in this TWP. This section lists organizations that use the outputs of this work.

TSPA Department

Before AMRs are issued, the Disruptive Events Department will coordinate work focus with this group to ensure that outputs of the work covered by this TWP will be appropriate to support abstraction for analysis of igneous activity consequences. AMRs eventually issued to report the results of this work will be reviewed, as appropriate, by the TSPA Department.

Outputs that will be used directly by the TSPA Department include the data and work to be documented in *Atmospheric Dispersal and Deposition of Tephra from a Potential Volcanic Eruption at Yucca Mountain, Nevada* (MDL-MGR-GS-000002) and the revision of *Number of Waste Packages Hit by Igneous Intrusion* (CRWMS M&O 2000c); and the probability of intersection to be documented in the revision of *Characterize Framework for Igneous Activity at Yucca Mountain, Nevada* (CRWMS M&O 2000a).

The TSPA Department model and analysis for Volcanic Eruption Dose will use the first of the listed AMRs as the basis for the analysis of ash/waste dispersion during an eruptive event. The outputs of the analysis documented in the model report will include the prediction of ash/waste concentration over a spatial distribution and a particle size distribution. The model report will also document the technical basis for selected parameter values and ranges in uncertainty to be incorporated into the TSPA-LA.

Additionally, the TSPA Department will use the outputs documented in the revision of *Number of Waste Packages Hit by Igneous Intrusion* (CRWMS M&O 2000c). Specifically, for the eruptive scenario, the TSPA-LA model will use the number of waste packages affected by an eruptive conduit and the number of waste packages that occur within defined magmatic-related

environmental zones. The magmatic-related environmental zones will be jointly defined by the TSPA and the Disruptive Events Departments based on the results to be presented in *Dike Propagation Near Drifts* (CRWMS M&O 2000b).

Similarly, the TSPA Department's model and analysis for the Igneous Intrusion Groundwater Dose will use the description of in-drift environmental conditions following an igneous intrusion from *Dike Propagation Near Drifts* (CRWMS M&O 2000b) as a technical basis for zoning the TSPA-LA model to reflect spatially varying effects of a volcanic event. For this analysis, the TSPA Department will also consider the number of waste packages exposed to the defined magmatic-related environmental zones as documented in *Number of Waste Packages Hit by Igneous Intrusion* (CRWMS M&O 2000c).

The TSPA Department's modeling and analysis approach for determining the consequences of an igneous event are based on a conditional calculation that assumes the occurrence of an event and then applies a probability weighting to that event. The probability distribution for an igneous event is an output of the probability estimates to be provided in the revision of *Characterize Framework for Igneous Activity at Yucca Mountain, Nevada* (CRWMS M&O 2000a). The analysis report will document the development of the probability distribution based on results of an expert elicitation process and application of those results to the repository design for TSPA-LA.

The TSPA-LA model developed by the TSPA Department will use a rate parameter(s) in its description of the erosion and accretion of volcanic ash in the vicinity of the RMEI. The rate parameter(s) will be based on the output of the Tephra redistribution studies being conducted as part of the Disruptive Events Field Investigations activity. The results of the study, including determination of the rate parameter, will be documented in the revision of *Characterize Eruptive Processes at Yucca Mountain, Nevada* (BSC 2001a). The analysis report will contain an analysis that calculates erosion/accretion rates using field measurements. The TSPA Department will incorporate the erosion/accretion rates into the TSPA-LA model, in consort with the Biosphere Department and Disruptive Events Department.

Biosphere Department

AMRs eventually issued to report the results of this work will be reviewed, as appropriate, by the Biosphere Department. The outputs of the various Disruptive Events AMRs are of a nature that supports work by this group for analysis of the effects of igneous activity (primarily ashfall-related effects). The Biosphere Department will use the results to be documented in *Atmospheric Dispersal and Deposition of Tephra from a Potential Volcanic Eruption at Yucca Mountain, Nevada* (MDL-MGR-GS-000002) and *Characterize Eruptive Processes at Yucca Mountain, Nevada* (ANL-MGR-GS-000002) to define the ranges over which the Biosphere model is appropriate. In particular, the Biosphere Department will use the range of ash thicknesses, the ash and waste particle size distributions, and the duration of a volcanic event developed by the Disruptive Events Department.

Waste Package Department and Waste Form Department

The outputs from the revision of *Dike Propagation Near Drifts* (CRWMS M&O 2000b) will include in-drift magmatic-related environmental conditions (temperature, pressure and velocity of material) following an igneous intrusion as a function of the distance from the point of dike intersection. This information is being specifically developed for use by other organizations. If a trend is approved, the listed departments will be able to use the information to better define post-event damage states and impact to the performance of various proposed EBS components, waste form, and/or to establish damage-state zones. The damage-state zones will be defined based on whether waste packages are totally engulfed in magma or are exposed to some combination of magma, pyroclasts and magmatic gases. Equating of the environmental zones with waste package damage states will occur within the AMR to be developed by the Waste Package Department, or other department as assigned by YMP.

2.1 Peer Review of Igneous Consequences Plan

In FY 2002, a peer review panel was convened by the CSO to review proposed approaches for analyzing the consequences of igneous events (intrusive or eruptive) that may impact the repository. The expected results of the panel's review are their recommendations defining an appropriate scope of work for analysis of the potential consequences of igneous activity impacting the repository. The panel will review past, ongoing and proposed conceptual, mathematical, and numerical modeling work described by the Disruptive Events Department and work by scientists who have performed analyses in support of NRC evaluation of potential consequences of igneous activity as well as other applicable reports that may exist in the literature. The CSO is performing the work of convening and coordinating the work of the panel.

For the activity "Support peer review of igneous consequences plan," the Disruptive Events Department will interact with the CSO's representative and support the peer review. For the activity "Implement changes to igneous consequences analysis plans," the panel's recommendations will be assessed and any impact on the scope of work will be identified. This is not a modeling activity; therefore, the other items required for discussion under scientific approach and technical methods are not applicable.

2.2 Characterize Framework for Igneous Activity at Yucca Mountain, Nevada

The Igneous Framework Conceptual Model will describe systems, processes, and phenomena that comprise the framework for igneous activity in the Yucca Mountain region consistent with the volcanic and tectonic history of the region. The results of an expert elicitation, the PVHA, are an important source of information for this conceptual model. The conceptual model supports analyses that include calculating the probability of a basaltic dike intersecting the repository footprint.

2.2.1 Intended Use and Purpose

Characterize Framework for Igneous Activity at Yucca Mountain (CRWMS M&O 2000a) contains a description of the conceptual framework of igneous activity in the Yucca Mountain region consistent with the volcanic and tectonic history of the region. It also summarizes the assessment of the igneous history by experts who participated in the PVHA expert elicitation,

which includes consideration and weighting of multiple alternative conceptual models. This constitutes the Igneous Framework Conceptual Model as documented in the analysis report. The report also documents the probability of a basaltic dike intersecting the repository footprint, the number of eruptive centers (conduits) within the repository footprint, and the length and azimuth of intersecting dikes within the repository footprint.

The work will produce a revision of *Characterize Framework for Igneous Activity at Yucca Mountain, Nevada* (CRWMS M&O 2000a), to be completed in FY 2003. The purpose of this revision is to perform and document a revised analysis of the probability of a basaltic dike intersecting the repository footprint. The revision will document the results of FY 2002 and FY 2003 activities and will update the Igneous Framework Conceptual Model based on new geophysical studies, probability studies, or tectonic studies published since REV 00 ICN 01 of the analysis report.

2.2.2 Scientific Approach and Technical Methods

The YMP is required to assess the potential impact of new data received after an expert elicitation. In early FY 2002, the Disruptive Events Department coordinated activities with the USGS, which was examining new aeromagnetic data to assess whether these data might represent the presence of buried volcanic anomalies of the type that would be of importance to the probability outputs of the PVHA. The USGS has published an Open-File Report on the assessment, *Aeromagnetic Expression of Buried Basaltic Volcanoes Near Yucca Mountain, Nevada* (O'Leary et al. 2002). The Disruptive Events Department will use the results of that report for the activity "Assess impact of new aeromagnetic survey results on probability," and perform an analysis to assess its potential implications for the probability of intersection of the repository by an igneous event. Final results will be provided in the analysis report in FY 2003.

The approach will be to evaluate the number of volcanic event counts represented by the data consistent with the approach used by experts in the PVHA, which will then allow a determination of the number of eruptive centers within the repository footprint and the length and azimuth of dikes that intersect the footprint.

Using 1) an analysis of new aeromagnetic data that may indicate the presence of additional buried volcanic centers in the region, and 2) a modified TSPA-LA repository footprint, a suite of software routines developed previously will be employed to determine the probability of intersection of the repository by a volcanic event. The probability of intersection of the repository by a volcanic event also has the potential to change with changes in the geographic location and geometry of the repository footprint. For the activity "Update probability calculation using the LA footprint," the probability of intersection of the repository by a volcanic event will be recalculated in FY 2003 using the LA footprint proposed at the time of the analysis.

2.2.3 Uncertainty Considerations

Because the aeromagnetic data are subject to varying interpretation with regard to the timing and number of volcanic events, the interpretation of the data represents a potentially significant uncertainty. To address the impact of this uncertainty, sensitivity calculations will be performed to assess impacts to the probability of intersection of the repository footprint, using several scenarios including "best estimate" and "worst case." These will be reflected in a probability distribution for the probability of intersection, developed per Appendix A of *Scientific Processes*

Guidelines Manual (BSC 2002b). This will be documented in the revision of *Characterize Framework for Igneous Activity at Yucca Mountain, Nevada* (CRWMS M&O 2000a).

2.2.4 Features, Events, and Processes

This activity will augment the technical basis for including the igneous-related FEPs by better defining the associated probability and updating the igneous framework conceptual model as appropriate. See Tables 3 and 4 for related FEPs. Related FEPs that have been included will be documented in the revision of *Characterize Framework for Igneous Activity at Yucca Mountain, Nevada* (CRWMS M&O 2000a).

2.2.5 Use of Existing Model for Scientific Analysis per AP-SIII.9Q

The activities described constitute a scientific analysis using the models and routines that are the result of a documented expert elicitation project performed under quality control procedures applicable to the expert elicitation process. Because the igneous scenario in the TSPA-LA will be used to calculate a conditional dose, and the probabilities of a dike intersecting the repository and of a conduit intersecting a drift are used to probabilistically weight that conditional dose, the probability of the igneous event directly influences the probabilistic dose estimate. Therefore, a high degree of understanding of the associated uncertainties is needed. The basis of this analysis is the PVHA, which provides adequate support for a high level of understanding of the associated uncertainty. The model developed during the elicitation was applied in an analysis for TSPA-SR and will be applied in a similar manner for TSPA-LA. No further justification is needed.

2.2.6 Alternative Models or Technical Approaches

The PVHA considered and weighted multiple alternative conceptual models relating to determination of the volcanic hazard, and the consideration of alternative models has been previously documented in the PVHA. The revision of this analysis report will briefly discuss the various types of models considered as part of the PVHA and provide further citation to the PVHA. The analysis report will also update discussions regarding any additional alternative models that have been presented in peer-reviewed literature and evaluate whether there is a need to further consider such models. This will be documented in the revision of *Characterize Framework for Igneous Activity at Yucca Mountain, Nevada* (CRWMS M&O 2000a).

2.2.7 Model Use Outside of Intended Use, Limitations, or Range of Validity

This activity does not use the existing model outside of its intended use, limitation, or range of validity. Not applicable.

2.2.8 Level of Confidence

This activity is primarily a scientific analysis and does not involve mathematical model development. Not applicable.

2.2.9 Validation Methods and Validation Criteria

This activity is an analysis based on the results of a previously conducted expert elicitation process. Not applicable.

2.2.10 Independent Review

No independent review beyond the ongoing peer review process and the internal technical review required by AP-SIII.9Q is planned or required. Not applicable.

2.3 Characterize Eruptive Processes at Yucca Mountain, Nevada

The Eruptive Processes Conceptual Model will describe systems, processes, and phenomena that comprise natural volcanic systems of the type that could impact the repository and the parameters that can be used to describe their behavior. The model will include eruption dynamics, the nature and geometry of the subsurface "plumbing" of the system, the resultant surface deposits, and the volume of eruption. The Tephra Redistribution Conceptual Model (see Section 2.4) will describe processes and parameters by which erosion and mixing of ash and sediment impact the source term in the vicinity of the RMEI.

2.3.1 Intended Use and Purpose

Under work packages P4D1224DFU and ADET03, *Disruptive Events Field Investigations*, data will be collected to improve/update the characterization of physical volcanology in the Yucca Mountain region. In addition, data will be collected to develop a conceptual model and parameters for ash/sediment distribution in the Yucca Mountain region. In FY 2003, the characterization of physical volcanology and ash/sediment redistribution in the Yucca Mountain Region will be updated, analyzed, and documented in *Characterize Eruptive Processes at Yucca Mountain, Nevada* (BSC 2001a) under work package ADEM03.

2.3.2 Scientific Approach and Technical Methods

Analyses of the results of the field investigations and other work related to description of the physical volcanology of the Yucca Mountain Region and ash/sediment redistribution after an eruptive event will be contained in the revision of the eruptive processes analysis report. The field and laboratory studies method and approach are described in *Test Plan for Ash Redistribution, Lava Morphology, and Igneous Processes Studies* (BSC 2002a) and are briefly summarized in Sections 2.3.2.1 and 2.3.2.2.

The physical volcanology aspects of this activity will provide data and analyses on eruption dynamics and dike swarm geometry. The data and analyses will address the distribution and volumes of pyroclastic and effusive facies, xenolith content of pyroclastic deposits and lavas, vesicularity and morphology of pyroclasts, morphology of lavas, dike width, number of dikes in a swarm, and distance between dikes in a swarm. This work will be supported by field studies that describe the lateral distribution, thickness, stratigraphy, and grain sizes of pyroclastic facies and the morphological characteristics of lava flows at Lathrop Wells cone. Field and laboratory work will be performed to constrain the content of xenoliths in the eruptive products. Macroscopic xenolith volume can be estimated in the field. Laboratory work will include xenolith identification, grain size analyses, thin section and scanning electron microscopy to characterize xenolith type and/or abundance. Fieldwork will also contribute to development of YMP analog information.

The results of field, laboratory, and analytical studies of ash and sediment redistribution will be used to provide parameter values, ranges, and uncertainties for direct application in disruptive events modeling and analysis by the TSPA Department for the consequences of igneous activity. Parameters will include: surface sediment (ash and soil) erosion and deposition rates at Yucca Mountain, potential distribution of contaminated ash from a hypothetical eruption through a repository, and rate of transport of contaminated ash toward and away from the vicinity of the RMEI by eolian and fluvial processes.

2.3.2.1 Physical Volcanology in the Yucca Mountain Region

The Lathrop Wells Tephra sheet will be studied for the purpose of characterizing the Tephra sheet deposited from the Lathrop Wells volcanic center, the youngest of the Quaternary basaltic eruptive centers in the Yucca Mountain region. In this study, data will be collected and analyzed to characterize the physical characteristics of the pyroclastic facies of the volcanic ash, such as deposit thickness, particle size distribution of deposit, ash volume per unit volume of sediment, and nature of ash deposit (air fall, fluvial reworking and eolian reworking).

This study will include reviewing the literature on sedimentary processes that accompany analogous eruptions in semi-arid to arid climatic settings (e.g., Paricutin and Jarullo volcanoes in Mexico, Vulcano in Italy), compilation of previously-collected data on Tephra thickness and grain size, examination of geologic sample logs from nearby wells, and reconstruction of the Lathrop Wells Tephra sheet to determine how the ash was eroded and redistributed. Results of this study will contribute to updating the eruptive processes conceptual model.

Direct observations and measurements of analog basaltic volcanoes, their products, and Tephra dispersal and erosional patterns and processes will provide the appropriate analog information to apply to a potential volcanic disruption of a repository at Yucca Mountain.

2.3.2.2 Ash and Sediment Redistribution in the Yucca Mountain Region

The focus of these studies is to develop a geologic basis for the fate and transport of contaminated basaltic ash from hypothetical eruptions through a repository, after the eruptive products have been deposited in the form of a Tephra sheet. The data collected will support determining whether the vicinity of the RMEI is an area where sediment, potentially carrying waste, is accreting or eroding, primarily based on laboratory measurements of Cs-137 content. The data will provide a technical basis to test the assumption that the risk effects (i.e., effective annual dose) of eolian and fluvial remobilization of contaminated ash are bounded by conservative modeling assumptions in the TSPA-SR model for dose from contaminated ash in the vicinity of the RMEI.

Fieldwork will include sediment sampling to determine the bomb-pulse cesium (Cs-137) content and vertical distribution in sediments in the vicinity of the RMEI to establish an estimate of erosion or deposition rates. This Cs-137 was first produced approximately 50 years ago with the advent of atmospheric testing of nuclear weapons and can provide a marker for estimating the volume of sediment being transported down slopes and washes during the past five decades. Section 5.3.3 of *Test Plan for Ash Redistribution, Lava Morphology, and Igneous Processes Studies* (BSC 2002a) provides a more detailed description of the methods and approach for analyzing the field data, which is summarized as follows:

Two parameters will be calculated as part of the ash redistribution studies: (1) ash dilution rate (%/km) and (2) site erosion/aggradation rate (mm/50 yrs). The method used to obtain the dilution rate, will be by using a series of samples of ash/alluvium, to estimate for each sample, the volume of ash/volume of sediment (%) and calculate the ash dilution rate as the sample ash (%) vs. the down drainage distance (km) from the first sample in a series.

The site erosion/aggradation rate will be calculated using the 137Cs (Pico curries/gm) value for a sample. The sum of the 137Cs values for samples in the vertical profile at a site yields the column 137Cs value. The column values will be evaluated in relationship to the 137Cs reference values to determine if there is excess or a deficiency of 137Cs compared to the reference values. An excess of 137Cs at a site represents deposition over the last 50 yrs and a deficiency represents erosion of the site over the last 50 yrs. The ratio of site 137Cs over reference 137Cs values determines the amount of erosion or deposition at the site. The erosion/deposition value is prorated over the 50 yrs since 137Cs was created (in nuclear explosions) to obtain the erosion/aggradation rate at a site (mm/50yrs).

Data collected from this work will produce an improved technical basis for the conceptual model (and supporting parameters) used by TSPA-LA with regard to the dominant sedimentation process (erosional or accretionary). This conceptual model impacts whether the source term from contaminated ash in soil should be increased or decreased to reflect erosion or accretion at the site. The data collected will also support an improved technical basis for the parameter distribution for grain size that is relevant to the inhaled dose for the biosphere dose conversion factor analysis.

The ash/sediment redistribution field studies will provide an improved scientific basis to support development of conceptual models and descriptive parameters for the processes by which erosion redistributes volcanic ash (Tephra) toward the RMEI.

2.3.3 Uncertainty Considerations

In FY 2003, observational data and data from literature review will be used to develop parameter probability distributions per Appendix A of *Scientific Processes Guidelines Manual* (BSC 2002b). This will be documented in *Characterize Eruptive Processes at Yucca Mountain, Nevada* (BSC 2001a).

2.3.4 Features, Events, and Processes

This activity will augment the technical basis for including the igneous-related FEPs by better defining the eruptive processes that are likely to occur and by providing a stronger technical basis for dealing with FEPs related to ash redistribution following the eruption. See Tables 3 and 4 for related FEPs. Related FEPs that have been included will be documented in *Characterize Eruptive Processes at Yucca Mountain, Nevada* (BSC 2001a).

2.3.5 Use of Existing Model for Scientific Analysis per AP-SIII.9Q

The analysis portions of this analysis report activity do not involve the use of existing mathematical models to complete the scientific analysis. Not applicable.

2.3.6 Alternative Models or Technical Approaches

The FY 2002 and FY 2003 activities related to the analysis report are primarily analyses that evaluate observational data, applicable literature, and applicable conceptual models to derive parameter characteristics. Consequently, alternative models are considered within the context of the literature review and interpretation of field data and observations. The conceptual model components of this activity during FY 2003 will consider alternative models and technical approaches as required by AP-SIII.9Q. The analysis report in FY 2003 will update discussions regarding any alternative models that have been presented in peer-reviewed literature and evaluate whether there is a need to further consider such models. This will be documented in *Characterize Eruptive Processes at Yucca Mountain, Nevada* (BSC 2001a).

2.3.7 Model Use Outside of Intended Use, Limitations, or Range of Validity

This activity is primarily a scientific analysis and does not involve mathematical model development. Not applicable.

2.3.8 Level of Confidence

This activity is focused on parameter development and does not involve mathematical model development. Not applicable.

2.3.9 Validation Methods and Validation Criteria

This activity is a scientific analysis and does not involve mathematical model development. Not applicable.

2.3.10 Independent Review

No independent review beyond the ongoing peer review process and the internal technical review required by AP-SIII.9Q is planned or required. Not applicable.

2.4 Disruptive Events Field Investigations

The Tephra Redistribution Conceptual Model will describe geomorphic processes and their influence for the area around Yucca Mountain, particularly as these processes affect redistribution of the Lathrop Wells Tephra sheet and the erosion and/or deposition in the vicinity of the RMEI and the dose calculation for the volcanic eruption scenario. The conceptual model will examine fluvial and eolian processes and grain size changes. The model will be supported by the results of field investigations on ash and sediment redistribution and Tephra redistribution. The planning document, *Test Plan for Ash Redistribution, Lava Morphology, and Igneous Processes Studies* (BSC 2002a), is the primary source for fieldwork descriptions. The following discussion is provided at a summary level only.

In FY 2002, the Disruptive Events Department investigators, in coordination with the Natural Barrier–Testing Department, initiated the subject field activities. Support activities by the Natural Barrier–Testing Department may include creation of sample collection reports and associated documents related to sample curation. Support activities by the USGS include assistance in planning and execution of field activities. The field and laboratory investigations will continue into FY 2003.

2.4.1 Intended Use and Purpose

Data will be collected to support expanding the technical basis for the following elements of the Eruptive Processes Conceptual Model:

- The physical volcanology of the Lathrop Wells eruptive center in the Yucca Mountain region, including the facies of the deposits, which relate to eruption mechanisms, lava flow morphology, and the original extent and nature of fallout Tephra deposits
- The subsurface "plumbing" of volcanoes that are analogous to basaltic volcanoes in the Yucca Mountain region
- The surficial geomorphologic processes that control the redistribution of fallout Tephra deposits (fluvial and eolian processes) and the resulting depositional or erosional features.

2.4.2 Scientific Approach and Technical Methods

The methods and approaches for physical volcanology and ash/sediment redistribution field investigations are described in *Test Plan for Ash Redistribution, Lava Morphology, and Igneous Processes Studies* (BSC 2002a) and in Field/Laboratory Work Package(s) prepared per AP-5.2Q, *Testing Work Packages.*

Fieldwork approaches will include: surface sampling and visual examination to collect data that support determination of surface processes that could affect transport of contaminated ash erupted from a potential future volcanic event, and to support determination of the likely eruption characteristics of a potential igneous event that might impact the repository. Physical volcanology work includes examination of facies of the deposits that relate to eruption mechanisms, lava flow morphology, and the original extent and nature of fallout Tephra deposits. Results of this work will be presented in *Characterize Eruptive Processes at Yucca Mountain, Nevada* (BSC 2001a), to be issued by the Disruptive Events Department in FY 2003.

2.4.2.1 Physical Volcanology in the Yucca Mountain Region

See description under Section 2.3.2.1.

2.4.2.2 Ash and Sediment Redistribution in the Yucca Mountain Region

See description under Section 2.3.2.2.

2.4.3 Uncertainty Considerations

Data from literature review and field observations will be used to develop parameter probability distributions and will be documented in the revision to *Characterize Eruptive Processes at Yucca Mountain, Nevada* (BSC 2001a).

2.4.4 Features, Events, and Processes

See Tables 3 and 3 for FEPs related to *Characterize Eruptive Processes at Yucca Mountain, Nevada* (BSC 2001a).

2.4.5 Use of Existing Model for Scientific Analysis per AP-SIII.9Q

This activity supports a scientific analysis and does not involve the use of existing mathematical models to complete the scientific analysis. Not applicable.

2.4.6 Alternative Models or Technical Approaches

The activity involves fieldwork that supports a scientific analysis that develops observational data and reviews applicable literature and applicable conceptual models to derive various eruptive process and post eruption redistribution parameter characteristics. Consequently, alternative models will be considered within the context of the literature review and interpretation of field data. This will be documented in *Characterize Eruptive Processes at Yucca Mountain, Nevada* (BSC 2001a).

2.4.7 Model Use Outside of Intended Use, Limitations, or Range of Validity

This activity for FY 2002 and FY 2003 involves fieldwork that supports a scientific analysis and does not involve mathematical model development. Not applicable.

2.4.8 Level of Confidence

This activity for FY 2002 and FY 2003 involves fieldwork that supports parameter development and does not involve mathematical model development. Not applicable.

2.4.9 Validation Methods and Validation Criteria

This activity for FY 2002 and FY 2003 involves fieldwork and laboratory analysis that supports a scientific analysis and does not involve mathematical model development. Not applicable.

2.4.10 Independent Review

This activity for FY 2002 and FY 2003 involves fieldwork and no independent review is required. No independent review beyond the ongoing peer review process and the internal technical review required by AP-SIII.9Q for the reporting document is planned or required. Not applicable.

2.5 Dike Propagation Near Drifts

The Dike-Drift Interaction Conceptual Model describes processes and phenomena relevant to dike propagation through the repository host rock and relevant to the behavior of magma as it encounters and enters the repository drifts. The Dike-Drift Interaction Model will be semi-quantitative because only two areas of the conceptual model will be mathematically modeled.

For *Dike Propagation Near Drifts* (CRWMS M&O 2000b), there are two main divisions of the work: Dike Propagation and Magma and Gas Flow. Both divisions of the work will involve selecting and qualifying appropriate software code for performing the modeling and both will, therefore, follow all appropriate software qualification, verification, and model validation procedures. The model will not examine damage effects on EBS components.

2.5.1 Intended Use and Purpose

The Dike-Drift Interaction Conceptual Model will provide the basis for representing the pathway a representative dike, or swarm of dikes, would follow in response to stresses in the earth's crust and altered stresses and rock properties caused by excavation of drifts and thermal loading. It will also support modeling the interaction at the interface between the propagating dike and the drifts regarding movement of magmatic products into and down drifts and the initial transient shock wave development. As stated in Section 2.5, this conceptual model supports development of the two numerical models being documented in the model report. In addition, the conceptual model is important for comparison to an NRC alternative conceptual model regarding how dike propagation may proceed given the influence of the drifts.

The Dike Propagation numerical model component will be developed to calculate: a) the fracture propagation direction, as affected by the repository (thermal and topographic effects); b) the pressure conditions and dike parameters at the point of intersection with the repository for use as initial conditions for the magma-drift analysis (Magma and Gas Flow model component); c) the effect that magma loss into the repository has on subsequent dike growth; and d) the change in stresses on the repository due to the presence of the dike. The model output will provide support for determining the potential for initiation of new fractures or reopening of existing joints inside the drift as a result of dike-drift interaction, the likelihood of the dike continuing on its path at the initial point of dike-drift intersection or its being diverted, and the selected boundary conditions (related to dike propagation) for "leak-off" of magma into a drift. The Dike Propagation model component will accommodate changing conditions along the pathway to which the dike may react including the undisturbed area below the repository, the altered area around the repository and finally, conditions that apply as the dike continues upward after it has passed through the zone of influence of the repository.

Development of the Magma and Gas Flow model component analyzes the interaction of two-phase (melt and vapor) flow of magma with drifts. The Magma and Gas Flow model component will model conditions that could occur when pressurized magma encounters a representative emplacement drift and its influence on the rock properties near the drift. Phase changes and environmental conditions such as temperature and pressure will be modeled.

The Post-Event Conceptual Model will describe the potential state of emplacement drifts after a dike intrusion and will build on outputs of the Magma and Gas Flow model component. It will describe the magmatic products that could be found in drifts that are fully, or partially, engulfed in magma, that have pyroclasts, or that have products developed from magmatic gases. It will not describe EBS component damage conditions, but will describe the magmatic products and environmental conditions to which these elements may have been exposed.

2.5.2 Scientific Approach and Technical Methods

Development of the Dike Propagation model component will apply a fracture propagation approach using representative igneous dike properties to calculate key parameters such as dike width, dike pressure, and dike propagation velocity as the repository is approached and intersected. Dike path analysis will consider the possibility that pre-existing joints in the rock above the drifts could open, or that new joints may develop as the drifts fill with magma and gas, and pressure in the drifts builds up. This possibility will take into account: 1) the stress conditions existing around the drifts at different times after waste emplacement; and 2) the

presence of the dike. The evolution of subsidiary fractures (both reopened and newly generated) will be simulated in order to calculate the expected fracture opening, magma flow rate and, eventually, the volume of magma that reaches the ground surface. The effect of different model parameters and initial and boundary conditions on these predictions will be investigated, as well as those combinations of conditions that lead to the most conservative predictions, and the model response associated with these predictions.

Dike propagation analyses will include use of a numerical code, based on a displacement-discontinuity boundary element formulation. The code includes all essential elements necessary for simulation of hydrofracturing: fracture propagation, viscous fluid flow inside the fracture, and fluid leak-off in the surrounding formation. Fracture propagation is based on linearly elastic fracture mechanics. The approach is elastic, and assumes plane strain conditions of deformation. The sensitivity of the crack path to other model parameters (e.g., magma viscosity) and initial conditions (e.g., dike velocity at depth, or driving pressure) will be investigated.

The model will utilize an existing quantitative stress analysis to aid in evaluating how the stress field around the repository could influence the direction of propagation of a basaltic igneous dike. The thermo-mechanical analysis was utilized for planning the layout according to the *Lower-Temperature Subsurface Layout and Ventilation Concepts* (BSC 2001c); both hot (1.41 kW/m) and cold (1.0 kW/m) repository designs were considered. Analysis of the latest layout and repository footprint will be completed as a part of a drift seismic stability analysis. The predicted stress fields will be used in dike propagation analysis.

For the Magma and Gas-flow model component, the investigator will describe the interaction of two-phase flow of magma and gas with drifts and waste packages in drifts. The investigator will develop two- and three-dimensional mathematical models of potential shock waves and explosive events with open drifts, of the motion of magma and gas down drifts, of the forces exerted on drift walls and engineered components, and of the temperature histories experienced by drifts and engineered components. Those models will then be used to perform analyses to describe those interactions. The analytical approach will include a variety of scales, as well as modeling an empty drift and modeling a drift with an element simulating waste packages.

2.5.3 Uncertainty Considerations

Parameters used to address the stress field are not used directly by the TSPA-LA model and are used only to determine the viability of potential dike propagation conceptual models or in other intermediate geotechnical models.

For the Magma and Gas Flow analysis, the analysis will examine a range of potential conditions for each magma parameter that controls the characteristic of the flow conditions. No parameters are passed directly to TSPA-LA; rather, parameter time histories will be used by the waste form and waste package groups to determine possible damage states, which then will be passed to the TSPA-LA.

Regardless, in agreement with Appendix A of *Scientific Processes Guidelines Manual* (BSC 2002b), the investigators for both model components will provide the Abstraction Team Leader and the Parameter Team Leader with estimates of the range and distribution of the parameters used in the model components and the basis for those estimates. Sensitivity calculations for rock properties and magma properties will also be performed to assess impacts

on the potential dike propagation scenario. This information will be used in the consideration of uncertainty. This information will be documented in *Dike Propagation Near Drifts* (CRWMS M&O 2000b).

2.5.4 Features, Events, and Processes

This activity will augment the technical basis for including the FEPs related to dike propagation and dike-repository interaction by better defining the processes controlling dike propagation and environmental conditions resulting from a dike intersecting a drift. See Tables 3 and 4 for related FEPs. Related FEPs that are included will be documented in *Dike Propagation Near Drifts* (CRWMS M&O 2000b).

2.5.5 Use of Existing Model for Scientific Analysis per AP-SIII.9Q

This activity includes the development and validation of new models per AP-SIII.10Q. Not applicable.

2.5.6 Alternative Models or Technical Approaches

There is scant analog information for analyzing the interaction of a propagating dike with an engineered tunnel or drift. Consequently, a range of hypothetical conceptual models has been proposed, from the dike continuing unimpeded to the surface with minimal flow into the drift opening, to a conceptualized total diversion of the magma and gas flow through the drift and then continuing upward through an existing, but distant or newly propagated, fracture somewhere along the drift. The purpose of the proposed analyses are to evaluate the viability of the various conceptual models, and to incorporate a realistic conceptual model into the consequence estimates as appropriate per Appendix A of *Scientific Processes Guidelines Manual* (BSC 2002b). This information will be documented in the update of *Dike Propagation Near Drifts* (CRWMS M&O 2000b).

2.5.7 Model Use Outside of Intended Use, Limitations, or Range of Validity

This activity includes the development and validation of new models per AP-SIII.10Q, rather than extension of existing models. Once validated, no use outside of the intended use, limitation, or range of validity is anticipated. If such conditions are identified, the revised model will be revalidated as required per AP-SIII.10Q and/or associated requirements.

2.5.8 Level of Confidence

High. See Appendices A and B.

2.5.9 Validation Methods and Validation Criteria

See Appendices A and B. The model and model components originating from the activity directly support the definition of damage zones and the number of waste packages affected during an eruptive event. Consequently, the models require model validation Level III, consistent with the designations and definition in Table B1-1 of *Scientific Processes Guidelines Manual* (BSC 2002b).

2.5.10 Independent Review

One of the primary focuses of the ongoing peer review panel described in Section 2.1 is to review and evaluate the suitability of the planned dike-drift interaction models described in this section. The required skills of the reviewers, the review criteria, and the documentation provided to the reviewers will be documented in the peer review report being prepared by the peer review panel, per the request of the CSO, as previously described.

No independent review beyond the ongoing peer review process and the internal technical review required by AP-SIII.10Q is planned.

2.6 Atmospheric Dispersal and Deposition of Tephra from a Potential Volcanic Eruption at Yucca Mountain, Nevada

The ASHPLUME Conceptual Model will provide the basis, supported by analog descriptions, for the applicability of using the ASHPLUME code to model volcanic ash and waste dispersal in the volcanic eruption scenario. Support for this model will also include examination of other potentially applicable codes. Development of the model will use the Eruptive Processes Conceptual Model and comparison of the expected scenario characteristics with the types of phenomena modeled by ASHPLUME.

The ASHPLUME Mathematical Model is a code that, run separately or as a module of GoldSim, yields a distribution of results characterizing the uncertainty in the concentration of waste particles on the ground surface due to a volcanic eruption through the repository. A portion of the work on this model will include improving the technical basis for selected parameters used by the code. Examples include incorporation ratio, particle shape factor, and wind speed.

2.6.1 Intended Use and Purpose

For *Atmospheric Dispersal and Deposition of Tephra from a Potential Volcanic Eruption at Yucca Mountain, Nevada* (MDL-MGR-GS-000002), the investigator will document the atmospheric dispersal phenomenon conceptual model and the mathematical concepts on which the mathematical model is based. The ASHPLUME model will be used to provide ground level radioactive waste concentration estimates in the vicinity of the RMEI to the TSPA-LA model for the igneous eruption scenario.

2.6.2 Scientific Approach and Technical Methods

The mathematical model is based on the two-dimensional diffusion model described by Suzuki (1983). Because the scale of horizontal turbulence in the atmosphere is much greater than that of vertical turbulence, the two-dimensional diffusion model only considers horizontal diffusion. The model considers diffusion of ash and combined ash/waste particles from an eruptive volcanic column, transfer of these particles in the atmosphere due to wind, horizontal diffusion of the particles due to atmospheric turbulence, and deposition of the particles on the ground surface due to sinking.

2.6.3 Uncertainty Considerations

Large uncertainties exist in ASHPLUME model input parameters due to the uncertainty of future atmospheric conditions at the time of the hypothetical eruption and uncertainty in the characterization of the physical attributes of a future eruption. Based on the observational data and data from literature review presented in the related Disruptive Event AMRs, the uncertainty in parameters used in ASHPLUME will be documented per Appendix A of the *Scientific Processes Guidelines Manual* (BSC 2002b). This will be documented in *Atmospheric Dispersal and Deposition of Tephra from a Potential Volcanic Eruption at Yucca Mountain, Nevada* (MDL-MGR-GS-000002).

2.6.4 Features, Events, and Processes

This activity will better define processes associated with eruptive conditions and resulting ash dispersion. See Tables 3 and 4 for related FEPs. Related FEPs that are included will be documented in *Atmospheric Dispersal and Deposition of Tephra from a Potential Volcanic Eruption at Yucca Mountain, Nevada* (MDL-MGR-GS-000002).

2.6.5 Use of Existing Model for Scientific Analysis per AP-SIII.9Q

The code ASHPLUME Version 1.4LV was previously used within GoldSim in the TSPA-SR to model dispersal of ash and waste for the volcanic eruption scenario. *Igneous Consequence Modeling for TSPA-SR* (BSC 2001d) documented the qualified use of the ASHPLUME code and also described elements of the abstraction for the igneous activity scenarios. For TSPA-LA, that AMR will not be revised. Furthermore, scientific analysis and models are now addressed by separate procedures.

Although similar in nature to the previous AMR, *Atmospheric Dispersal and Deposition of Tephra from a Potential Volcanic Eruption at Yucca Mountain, Nevada,* is a new model report, rather than a revision of the existing AMR. Consequently, the ASHPLUME model and analysis will be performed and documented per the requirements of AP-SIII.10Q, *Models*. The new model report will provide stand-alone documentation of the ASHPLUME model and will also contain validation for the model such that the model can be used for later scientific analyses. Analysis documented in the new model report will improve and clarify the previous documentation of the code and its application to TSPA-LA igneous scenarios. Expected outputs of the model report include prediction of ash/waste distributions and particle size distributions for the volcanic eruption scenario.

2.6.6 Alternative Models or Technical Approaches

The new model report will provide a brief discussion and a literature review of other codes or models considered for possible use in the TSPA. If an alternative model is identified as appropriate, it will be used to corroborate the ASHPLUME results per Appendix A of *Scientific Processes Guidelines Manual* (BSC 2002b). If no suitable code or model is identified, then the results of ASHPLUME will be compared to a simple Gaussian plume model. This will be documented in *Atmospheric Dispersal and Deposition of Tephra from a Potential Volcanic Eruption at Yucca Mountain, Nevada* (MDL-MGR-GS-000002).

2.6.7 Model Use Outside of Intended Use, Limitations, or Range of Validity

No use outside of the intended use, limitation, or range of validity is anticipated. If such conditions are identified, the revised model will be revalidated as required per AP-SIII.10Q and/or associated requirements.

2.6.8 Level of Confidence

High. See Appendix C.

2.6.9 Validation Methods and Validation Criteria

See Appendix C. The model and model components originating from the activity directly support the determination of the consequences of an eruptive event. Consequently, the model requires model validation Level III, consistent with the designations and definition in Table B1-1 of *Scientific Processes Guidelines Manual* (BSC 2002b).

2.6.10 Independent Review

The use of ASHPLUME is subject to review by the ongoing peer review panel described in Section 2.1. The required skills of the reviewers, the review criteria, and the documentation provided to the reviewers will be documented in the peer review report being prepared by the peer review panel per the request of the CSO, all as described above.

No independent review beyond the ongoing peer review process and the internal technical review required by AP-SIII.10Q is planned.

2.7 Number of Waste Packages Hit by Igneous Intrusion

Number of Waste Packages Hit by Igneous Intrusion, (CRWMS M&O 2000c), will be revised and reissued as an analysis report in FY 2003. The investigator will document the recalculation of waste packages hit based on updates and revisions to the supporting AMRs.

2.7.1 Intended Use and Purpose

The analysis uses a variety of information documented in supporting AMRs to calculate how many waste packages are exposed to varying conditions associated with igneous activity intersecting the repository. The types of information include, but may not be limited to:

- Repository design information (repository area, drift spacing, waste package length, and waste package spacing)
- Igneous event probability
- Probabilities and parameters associated with conduits occurring within the repository (conditional probability that more than one conduit will occur within the repository footprint and conduit diameter distribution)
- Probability distributions and parameters associated with dikes within the repository (dike length, dike azimuth angle, dike width and number of dikes in a swarm).

For TSPA-SR, the number of waste packages hit calculation and igneous consequences AMR together produced the number of waste packages hit and an estimate of the damage state of the waste packages. The previous AMR, *Igneous Consequences Modeling for TSPA-SR* (BSC 2001d), will not be revised. For TSPA-LA, the number of waste packages hit calculation will not contain statements regarding damage states associated with exposure to magmatic environments, unless that information is supplied from an analysis by a group outside of the Disruptive Events Department. The Project is in the process of determining the level of funding needed to perform the waste package damage analyses and designating the department responsible for performing and documenting the analyses (See Section 2). *Number of Waste Packages Hit by Igneous Intrusion* (CRWMS M&O 2000c) will, however, provide output regarding the number of waste packages exposed to various magmatic-related environments.

2.7.2 Scientific Approach and Technical Methods

The analysis uses spreadsheet calculation operations to evaluate geometric relationships between dike intersection area and conduit geometry, and the number of waste packages impacted by dikes and conduits.

The report will use the outputs from the revisions of *Characterize Framework for Igneous Activity at Yucca Mountain, Nevada* (CRWMS M&O 2000a), *Characterize Eruptive Processes at Yucca Mountain, Nevada* (BSC 2001a); and *Dike Propagation Near Drifts* (CRWMS M&O 2000b) along with repository design information to calculate the number of waste packages exposed to defined magmatic-related environments. For the volcanic eruption scenario, the number of waste packages within an eruptive conduit will be calculated. For the igneous intrusion groundwater scenario, the number of waste packages exposed to various magmatic-related environments will be calculated.

2.7.3 Uncertainty Considerations

This analysis addresses uncertainty by using probability distributions and cumulative distribution functions to determine the parameters that affect the calculation of the number of waste packages hit. This uncertainty treatment will be documented in the AMR in accordance with Appendix A of *Scientific Processes Guidelines Manual* (BSC 2002b). This will be documented in *Number of Waste Packages Hit by Igneous Intrusion* (CRWMS M&O 2000c).

2.7.4 Features, Events, and Processes

This activity will augment the technical basis for including the FEPs related to dike-repository interaction by better defining the number of waste packages affected by igneous activity. See Tables 3 and 4 for related FEPs. Related FEPs that are included will be documented in *Number of Waste Packages Hit by Igneous Intrusion* (CRWMS M&O 2000c).

2.7.5 Use of Existing Model for Scientific Analysis per AP-SIII.9Q

The activities described constitute a scientific analysis that will use qualified routines and may use models previously validated within the range, and consistent with, their intended use. Development and use of any new software routines, if applicable, will follow applicable procedures. No further justification is needed.

2.7.6 Alternative Models or Technical Approaches

This analysis uses the types of information described in Subsection 2.7.1 to calculate the number of waste packages hit by an igneous event. The output of the analysis is a cumulative distribution function of the number of waste packages affected. Any alternative models or technical approaches will be reflected in the data distributions documented in the supporting AMRs. Therefore, alternative models or approaches are inherently incorporated or excluded depending on their status as documented in the supporting AMRs. Because this is an analysis, the consideration of alternative models is not applicable. Any assumptions regarding the spatial distribution of conduits in relation to drifts and waste packages will be documented as required per AP-SIII.9Q.

2.7.7 Model Use Outside of Intended Use, Limitations, or Range of Validity

This activity is a scientific analysis and does not involve mathematical model development. Not applicable.

2.7.8 Level of Confidence

This activity is focused on parameter development and does not involve mathematical model development. Not applicable.

2.7.9 Validation Methods and Validation Criteria

This activity is a scientific analysis and does not involve mathematical model development. Not applicable.

2.7.10 Independent Review

No independent review beyond the ongoing peer review process and the internal technical review required by AP-SIII.9Q is planned or required. Not applicable.

2.8 Roadmap to Igneous Activity Models, Analyses, and Calculations

In FY 2002, an annotated outline for a new technical report was produced that will support production of *Roadmap to Igneous Activity Models, Analyses, and Calculations* (TDR-WIS-MD-000006) during FY 2003.

2.8.1 Intended Use and Purpose

The purpose of this document is to support transparency and traceability of the analyses, models, and calculations for igneous activity probability and consequences. The roadmap document will clarify the sources of parameter development and will support TSPA-LA documentation of the two igneous activity scenarios and their abstraction. The annotated outline will support interaction with the peer review panel in FY 2003. The document will clarify the flow of information into and out of the Disruptive Events Department igneous activity documents. In part, it replaces the function of *Igneous Consequences Modeling for TSPA-SR* (BSC 2001d).

In contrast, however, the roadmap document will not be a source of data for the TSPA-LA. This is a summary document being prepared to enhance transparency and traceability, and it does not provide the technical documentation for models or model components. The Disruptive Events Department AMRs previously described will be the source of data for igneous activity analysis. Therefore, the other items required for discussion under scientific approach and technical methods are not applicable.

3. STANDARDS AND CRITERIA

Documents will be prepared to meet requirements specified in the governing implementing procedures and guidelines applicable at the time. Model validation criteria associated with this TWP are addressed in Appendices A, B, and C.

There are no predefined requirements for the accuracy, precision, and representativeness of the results. Scientists and others carrying out the work will coordinate with users of the results to establish specific requirements as the work develops and will describe uncertainties and the representativeness of results, as appropriate.

The activities described in this TWP will be subject to regulatory review per the provisions and criteria of *Yucca Mountain Review Plan* (NRC 2002). The criteria specific to igneous activity probability and consequence are provided in Tables 5 and 6. Regulatory review will also include review of the completion of KTI agreements as documented in Appendices A and B of *Yucca Mountain Review Plan* (NRC 2002).

4. IMPLEMENTING DOCUMENTS

All quality-affecting tasks, such as modeling, analysis, and report development, will meet the requirements of *Quality Assurance Requirements and Description* (DOE 2002). Site-specific data needed for the TSPA-LA that is acquired or developed by the Disruptive Events Department through the Disruptive Events testing program and modeling and analysis activities will be qualified and submitted to the TDMS. These activities will support data management, verification, and other quality assurance (QA) activities needed to produce revisions of existing AMRs and will develop new reports as described in the following paragraphs, in compliance with implementing procedures.

Key implementing documents are:

- AP-SIII.9Q, *Scientific Analyses*
- AP-SIII.10Q, *Models*
- AP-3.11Q, *Technical Reports*
- AP-3.15Q, *Management of Technical Product Inputs*
- AP-SI.1Q, *Software Management*
- AP-SIII.2Q, *Qualification of Unqualified Data and the Documentation of Rationale for Accepted Data*
- AP-SIII.1Q, *Scientific Notebooks*
- AP-SIII.3Q, *Submittal and Incorporation of Data to the Technical Data Management System*

Table 5. List of Yucca Mountain Review Plan Acceptance Criteria for Volcanic Disruption of Waste Packages.

Acceptance Criterion	Topic	Specific Considerations	Comments
1	System Description and Model Integration Are Adequate	• Total system performance assessment adequately incorporates important design features, physical phenomena, and couplings, and uses consistent and appropriate assumptions throughout the volcanic disruption of waste packages abstraction process;	See; *Characterize Framework for Igneous Activity at Yucca Mountain, Nevada* (CRWMS M&O 2000a); and *Dike Propagation Near Drifts* (CRWMS M&O 2000b).
		• Models used to assess volcanic disruption of waste packages are consistent with physical processes generally interpreted from igneous features in the Yucca Mountain region and/or observed at active igneous systems;	See *Characterize Framework for Igneous Activity at Yucca Mountain, Nevada* (CRWMS M&O 2000a) and *Dike Propagation Near Drifts* (CRWMS M&O 2000b).
		• Models account for changes in igneous processes that may occur from interactions with engineered repository systems; and	See *Dike Propagation Near Drifts* (CRWMS M&O 2000b).
		• Guidance in NUREG-1297 (NRC 1988a) and NUREG-1298 (NRC 1988b) or in other acceptable approaches for peer review and data qualification is followed.	The probability of an igneous event within the repository is based on the findings of an expert elicitation previously documented in *Probabilistic Volcanic Hazard Analysis for Yucca Mountain, Nevada* (CRWMS M&O 1996) and updated for various repository footprints in *Characterize Framework for Igneous Activity at Yucca Mountain, Nevada* (CRWMS M&O 2000a).

Table 5. List of Yucca Mountain Review Plan Acceptance Criteria for Volcanic Disruption of Waste Packages (Continued).

Acceptance Criterion	Topic	Specific Considerations	Comments
2	Data Are Sufficient for Model Justification	• Parameter values used in the safety case to evaluate volcanic disruption of waste packages are sufficient and adequately justified. Adequate descriptions of how the data were used, interpreted, and appropriately synthesized into the parameters are provided;	See *Characterize Framework for Igneous Activity at Yucca Mountain, Nevada* (CRWMS M&O 2000a) and *Dike Propagation Near Drifts* (CRWMS M&O 2000b).
		• Data used to model processes affecting volcanic disruption of waste packages are derived from appropriate techniques. These techniques may include site-specific field measurements, natural analog investigations, and laboratory experiments;	See *Characterize Eruptive Processes at Yucca Mountain, Nevada* (BSC 2001a), *Characterize Framework for Igneous Activity at Yucca Mountain, Nevada* (CRWMS M&O 2000a) and *Dike Propagation Near Drifts* (CRWMS M&O 2000b).
		• Sufficient data are available to integrate features, events, and processes, relevant to volcanic disruption of waste packages into process-level models, including determination of appropriate interrelationships and parameter correlations; and	See *Characterize Eruptive Processes at Yucca Mountain, Nevada* (BSC 2001a), and *Characterize Framework for Igneous Activity at Yucca Mountain, Nevada* (CRWMS M&O 2000a).
		• Where sufficient data do not exist, the definition of parameter values and associated conceptual models is based on appropriate use of expert elicitation conducted, in accordance with NUREG-1563 (Kotra et al. 1996). If other approaches are used, the DOE adequately justifies their use.	The probability of an igneous event within the repository is based on the findings of an expert elicitation previously documented in *Probabilistic Volcanic Hazard Analysis for Yucca Mountain, Nevada* (CRWMS M&O 1996) and updated for various repository footprints in *Characterize Framework for Igneous Activity at Yucca Mountain, Nevada* (CRWMS M&O 2000a).

Table 5. List of Yucca Mountain Review Plan Acceptance Criteria for Volcanic Disruption of Waste Packages (Continued).

Acceptance Criterion	Topic	Specific Considerations	Comments
3	Data Uncertainty Is Characterized and Propagated Through the Model Abstraction	• Models use parameter values, assumed ranges, probability distributions, and/or bounding assumptions that are technically defensible, and reasonably account for uncertainties and variabilities;	See *Characterize Eruptive Processes at Yucca Mountain, Nevada* (BSC 2001a), and *Characterize Framework for Igneous Activity at Yucca Mountain, Nevada* (CRWMS M&O 2000a).
		• Parameter uncertainty accounts quantitatively for the uncertainty in parameter values derived from site data and the available literature (i.e., data precision), and the uncertainty introduced by model abstraction (i.e., data accuracy); and	See various related subsections in Section 2 of this TWP for AMR-specific discussions regarding the treatment of uncertainty and alternative conceptual models.
		• Where sufficient data do not exist, the definition of parameter values and associated uncertainty is based on appropriate use of expert elicitation conducted, in accordance with NUREG-1563 (Kotra et al. 1996). If other approaches are used, the U.S. Department of Energy adequately justifies their use.	The probability of an igneous event within the repository is based on the findings of an expert elicitation previously documented in *Probabilistic Volcanic Hazard Analysis for Yucca Mountain, Nevada* (CRWMS M&O 1996) and updated for various repository footprints in *Characterize Framework for Igneous Activity at Yucca Mountain, Nevada* (CRWMS M&O 2000a).
4	Model Uncertainty Is Characterized and Propagated Through the Model Abstraction	• Alternative modeling approaches to volcanic disruption of waste packages are considered and are consistent with available data and current scientific understandings, and the results and limitations are appropriately considered in the abstraction; and	See the discussion of consideration of alternative modeling approaches for determining probability previously documented in the *Probabilistic Volcanic Hazard Analysis for Yucca Mountain, Nevada* (CRWMS M&O 1996) and *Characterize Framework for Igneous Activity at Yucca Mountain, Nevada* (CRWMS M&O 2000a) and alternative interpretations of dike propagation mechanisms in *Dike Propagation Near Drifts* (ANL-WIS-MD-000015).
		• Uncertainties in abstracted models are adequately defined and documented, and effects of these uncertainties are assessed in the total system performance assessment.	See various related subsections in Section 2 of this TWP for AMR-specific discussions regarding the treatment of uncertainty and alternative conceptual models.
5	Model Abstraction Output Is Supported by Objective Comparisons	• Models implemented in the volcanic disruption of waste packages abstraction provide results consistent with output from detailed process-level models and/or empirical observations (laboratory and field testings and/or natural analogs); and	See various related subsections in Section 2 of this TWP for AMR-specific discussions regarding the treatment of uncertainty and alternative conceptual models.
		• Inconsistencies between abstracted models and comparative data are documented, explained, and quantified. The resulting uncertainty is accounted for in the model results.	See various related subsections in Section 2 of this TWP for AMR-specific discussions regarding the treatment of uncertainty and alternative conceptual models.

Table 6. List of Yucca Mountain Review Plan Acceptance Criteria for Airborne Transport of Radionuclides.

Acceptance Criterion	Topic	Specific Considerations	Comments
1	System Description and Model Integration Are Adequate	• Total system performance assessment adequately incorporates important design features, physical phenomena, and couplings, and uses consistent and appropriate assumptions throughout the airborne transport of radionuclides abstraction process;	See *Features, Events, and Processes: Disruptive Events* (CRWMS M&O 2000e).
		• Models used to assess airborne transport of radionuclides are consistent with physical processes generally interpreted from igneous features in the Yucca Mountain region and/or observed at active igneous systems;	See *Characterize Eruptive Processes at Yucca Mountain, Nevada* (BSC 2001a) and *Atmospheric Dispersal and Deposition of Tephra from a Potential Volcanic Eruption at Yucca Mountain, Nevada* (MDL-MGR-GS-000002).
		• Models account for changes in igneous processes that may occur from interactions with engineered repository systems; and	See *Dike Propagation Near Drifts* (CRWMS M&O 2000b).
		• Guidance in NUREG-1297 (NRC 1988a) and NUREG-1298 (NRC 1988b), or in other acceptable approaches for peer review and data qualification is followed.	The probability of an igneous event within the repository is based the findings of an expert elicitation documented in *Probabilistic Volcanic Hazard Analysis for Yucca Mountain, Nevada* (CRWMS M&O 1996) and updated for various repository footprints in *Characterize Framework for Igneous Activity at Yucca Mountain, Nevada* (CRWMS M&O 2000a).

Table 6. List of Yucca Mountain Review Plan Acceptance Criteria for Airborne Transport of Radionuclides (Continued).

Acceptance Criterion	Topic	Specific Considerations	Comments
2	Data Are Sufficient for Model Justification	• Parameter values used in the safety case to evaluate airborne transport of radionuclides are sufficient and adequately justified. Adequate descriptions of how the data were used, interpreted, and appropriately synthesized into the parameters are provided;	See *Atmospheric Dispersal and Deposition of Tephra from a Potential Volcanic Eruption at Yucca Mountain, Nevada* (MDL-MGR-GS-000002).
		• Data used to model processes affecting airborne transport of radionuclides are derived from appropriate techniques. These techniques may include site-specific field measurements, natural analog investigations, and laboratory experiments;	See *Characterize Eruptive Processes at Yucca Mountain, Nevada* (BSC 2001a) and *Atmospheric Dispersal and Deposition of Tephra from a Potential Volcanic Eruption at Yucca Mountain, Nevada* (MDL-MGR-GS-000002)
		• Sufficient data are available to integrate features, events, and processes, relevant to airborne transport of radionuclides into process-level models, including determination of appropriate interrelationships and parameter correlations; and	See *Characterize Eruptive Processes at Yucca Mountain, Nevada* (BSC 2001a) and *Atmospheric Dispersal and Deposition of Tephra from a Potential Volcanic Eruption at Yucca Mountain, Nevada* (MDL-MGR-GS-000002)
		• Where sufficient data do not exist, the definition of parameter values and associated conceptual models is based on appropriate use of expert elicitation conducted, in accordance with NUREG-1563 (Kotra et al. 1996). If other approaches are used, the U.S. Department of Energy adequately justifies their use.	No expert elicitation is used to define the parameter values or conceptual model for atmospheric transport.

Table 6. List of Yucca Mountain Review Plan Acceptance Criteria for Airborne Transport of Radionuclides (Continued).

Acceptance Criterion	Topic	Specific Considerations	Comments
3	Data Uncertainty Is Characterized and Propagated through the Model Abstraction	• Models use parameter values, assumed ranges, probability distributions, and/or bounding assumptions that are technically defensible, and reasonably account for uncertainties and variabilities;	See *Characterize Eruptive Processes at Yucca Mountain, Nevada* (BSC 2001a) and *Atmospheric Dispersal and Deposition of Tephra from a Potential Volcanic Eruption at Yucca Mountain, Nevada* (MDL-MGR-GS-000002).
		• Parameter uncertainty accounts quantitatively for the uncertainty in parameter values derived from site data and the available literature (i.e., data precision), and the uncertainty introduced by model abstraction (i.e., data accuracy); and	See various related subsections in Section 2 of this TWP for AMR-specific discussions regarding the treatment of uncertainty and alternative conceptual models.
		• Where sufficient data do not exist, the definition of parameter values and associated uncertainty is based on appropriate use of expert elicitation conducted, in accordance with NUREG-1563 (Kotra et al. 1996). If other approaches are used, DOE adequately justifies their use.	No expert elicitation is used to define the parameter values or conceptual model for atmospheric transport.
4	Model Uncertainty is Characterized and Propagated through the Model Abstraction	• Alternative modeling approaches to airborne transport of radionuclides are considered and are consistent with available data and current scientific understandings, and the results and limitations are appropriately considered in the abstraction; and	See the discussion of consideration of alternative modeling approaches documented in *Atmospheric Dispersal and Deposition of Tephra from a Potential Volcanic Eruption at Yucca Mountain, Nevada* (MDL-MGR-GS-000002) and the bases of selecting ASHPLUME.
		• Uncertainties in abstracted models are adequately defined and documented, and effects of these uncertainties are assessed in the total system performance assessment.	The use of *ASHPLUME* does not involve a model abstraction.
5	Model Abstraction Output is Supported by Objective Comparisons	• Models implemented in the airborne transport of radionuclide abstraction provide results consistent with output from detailed process-level models and/or empirical observations (laboratory and field testings and/or natural analogs); and	See the discussion of the distribution of the Lathrop Wells Tephra sheet in *Characterize Eruptive Processes at Yucca Mountain, Nevada* (BSC 2001a) and the model validation portion of *Atmospheric Dispersal and Deposition of Tephra from a Potential Volcanic Eruption at Yucca Mountain, Nevada* (MDL-MGR-GS-000002).
		• Inconsistencies between abstracted models and comparative data are documented, explained, and quantified. The resulting uncertainty is accounted for in the model results.	The use of ASHPLUME does not involve a model abstraction.

- AP-SIII.7Q, *Scientific Investigation Laboratory and Field Testing*
- AP-5.2Q, *Testing Work Packages*
- AP-2.27Q, *Planning for Science Activities.*

Existing administrative procedures for the YMP (AP-SI.1Q, AP-SIII.9Q, AP-SIII.10Q, and AP-AC.1Q) will be used to control the work during development of the AMRs. The AMRs will also address the guidelines, issues, and recommendations in *Scientific Processes Guidelines Manual* (BSC 2002b). In support of the modeling work, scientists and investigators have been directed to use scientific notebooks in accordance with AP-SIII.1Q, and data use and transmittal will be governed by AP-3.15Q, AP-SIII.2Q, and AP-SIII.3Q. *Roadmap to Igneous Activity Models, Analyses, and Calculations* (TDR-WIS-MD-000006) will be prepared in accordance with AP-3.11Q.

In addition, procedures referenced in the above implementing documents and procedures for support activities (e.g., document control, records management) will also be used to control the work effort. If any of the key implementing documents is superseded, work will take place in accordance with the new document.

As previously indicated, field investigations are being performed in accordance with AP-SIII.7Q and AP-5.2Q. Testing and Monitoring (TWP-MGR-MD-000018, REV 00), which is a TWP developed for a work package in the Natural Barrier–Testing Department for activities that support field investigations, contains a listing of available services (e.g., Test Coordination Office, Sample Management Facility, etc.) for supporting work packages P4D1224DFU and ADET03 for Disruptive Events fieldwork. That TWP in combination with the documents associated with AP-SIII.7Q and the Field/Laboratory Work Package prepared for the Disruptive Events Field Investigation work package provides a list of the appropriate implementing documents for field investigations.

5. EQUIPMENT

Field or laboratory systems necessary to carry out the work scope, and any associated calibration requirements, will be described in the implementing documents for the fieldwork, *Test Plan for Ash Redistribution, Lava Morphology, and Igneous Processes Studies* (BSC 2002a).

6. RECORDS

Records identified in Section 6 of any implemented procedures (such as those listed in Section 4 of this TWP) will be collected and submitted to the Records Processing Center in accordance with AP-17.1Q, *Records Source Responsibilities for Inclusionary Records.*

7. QUALITY VERIFICATIONS

As indicated in Section 4, an Activity Evaluation has determined that some of the work described in this plan is subject to the requirements of *Quality Assurance Requirements and Description* (DOE 2002). The QA verifications to be performed, other than audits or surveillance, consist of the checking, review, and data verification activities specified in the governing implementing documents, including fieldwork-related plans and procedures.

8. PREREQUISITES, SPECIAL CONTROLS, ENVIRONMENTAL CONDITIONS, PROCESSES, OR SKILLS

8.1 Requirements from *Quality Assurance Requirements and Description*

All quality-affecting tasks, such as modeling, analysis, and report development, will meet the requirements of *Quality Assurance Requirements and Description* (DOE 2002). Site-specific data acquired or developed by the Disruptive Events Department through the Disruptive Events testing program and modeling and analysis activities will be qualified and submitted to the TDMS per AP-SIII.3Q or AP-SIII.2Q, as appropriate. This activity will support data management, verification, and other QA activities needed to produce revisions of existing AMRs and will develop new reports in compliance with implementing procedures and as described in the preceding sections. All of the activities discussed previously in the TWP are subject to the QA Program , with the exception of the following:

- Support of and participation in interactions with regulatory and oversight organizations (e.g., work necessary to support documenting progress on NRC agreements on KTIs)
- All activities necessary for progress, cost, and schedule status reporting
- Development and management of the work scope
- All preliminary, evaluative activities needed to determine whether particular approaches, tools, or products will be suitable for Project activities. For example, determining whether a particular model or software is usable for an analysis or whether particular instrumentation is suitable for data collection needs.

8.2 ISMQAP Requirements

The planning requirements for ISMQAP have been met with the completion of this TWP. Any specific ISMQAP and ISMS requirements have been addressed in the appropriate test plan or field work package and are described below.

This TWP addresses fieldwork under work packages P4D1224DFU and ADET03, Disruptive Events Field Investigation, and is being conducted by the Natural Barrier–Testing Department. That department has done their own grading of QA and QC controls. The following text is provided by the Natural Barrier–Testing Department and is from their TWP for fieldwork for several work packages under Sub-product Element 1.2.22.6.T owned by that group (TWP-MGR-MD-000018 Rev 00, Testing and Monitoring).

No special ISMS controls are applicable to the work identified in this TWP, as full application of ISMS controls is required as identified in lower level work planning and implementing documents (e.g., AP-5.2Q, *Testing Work Packages;* AP-ESH-008, *Hazard Analysis System;* and AP-2.23Q, *Work Request/Work Order Process*).

8.3 Prerequisites

Not applicable.

8.4 Electronic Management of Information (AP-SV.1Q)

An evaluation conducted per AP-SV.1Q, *Control of the Electronic Management of Information*, identifies that electronic data requiring controls are involved in this work (see Attachment 1, "Office of Civilian Radioactive Waste Management Process Control Evaluation for Supplement V"). Checksums and parity checks performed by computer operating systems during data transfer and storage using commonly available software and hardware, plus established computer security mechanisms, provide adequate assurance of the integrity of transferred data. Additional controls on electronic storage and transfer of data may be described in scientific notebooks documenting the work if scientific notebooks are used.

8.5 Ensurance of Defensible Results

Not applicable.

8.6 Special Environmental Controls

Special environmental conditions may be required for the fieldwork/sample collection covered by this TWP (work packages P4D1224DFU and ADET03). Those conditions are related to sample collection and curation. Investigators will determine whether and, if so, what conditions will be required and will specify them in the applicable SITPs or Field/Laboratory Work Package mentioned previously.

There are no special environmental conditions required for all other work packages covered by this TWP.

9. SOFTWARE

The work described in this TWP involves selection, qualification, verification and other software management activities for two or more software codes for modeling dike-drift interaction, and ASHPLUME, all of which is work being done under this TWP. The anticipated software codes include:

Table 7. Models, Software, STNs, and Qualification Status.

Model	Software	STN:	Qualification Status
Dike Propagation Model Component	NPHF2D Version 1.0	10904-1.0-00	Not qualified, in process
Magma and Gas Flow Model Component	CFDLIB Version 0.20	10846-2.0-00	Not qualified, in process
ASHPLUME	ASHPLUME V1.4LV-DLL	10022-1.4LV-00	Not qualified, in process for PC version. UNIX version previously qualified with different STN

All software use will be in accordance with AP-SI.1Q, *Software Management*. Software qualification conducted under this activity is limited to software that will be taken forward to LA. Activities in FY 2003 primarily will focus on Data and Software Qualification/Verification and on analyses using the qualified software. The work will expand the technical basis for LA. As needed, preliminary data will be sent to the TDMS to support development of the TSPA-LA model.

Individual computational applications of Microsoft Excel are expected to be developed in one or more of the AMRs. Work packages P4D1224FDU and ADET03 will use SITP-02-DE-001, which includes a description of the software used in the field and laboratory work.

10. ORGANIZATION INTERFACES

The work described by this TWP is primarily for the Disruptive Events Department and includes work performed by the USGS and the Natural Barrier – Testing Department for Disruptive Events. The USGS will assist in planning and execution of field activities described in this work package. Work package 8191225DUA, Science Support to Disruptive Events, is managed by the USGS and covers USGS support to disruptive events fieldwork. The Disruptive Events Department will coordinate work focus, as appropriate.

Additionally, the work described herein is the subject of review of the igneous peer review panel, which has been convened under the auspices of the CSO. Recommendations from the igneous peer review panel will be considered and may influence the direction and activities described herein. There are no other interfaces with other organizations besides the input and customer organizations described in Section 2.

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